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(54) ARTICLE SORTING APPARATUS

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B65G 47/46 (2006.01)
B65G 17/34 (2006.01)

(52) **U.S. Cl.**
CPC ***B65G 43/08*** (2013.01); ***B65G 17/345*** (2013.01); ***B65G 47/46*** (2013.01); *B65G 2203/0233* (2013.01); *B65G 2811/0673* (2013.01)

(58) **Field of Classification Search**
CPC B65G 17/345; B65G 43/08; B65G 47/46; B65G 2203/0233; B65G 2811/0673
USPC 198/370.06
See application file for complete search history.

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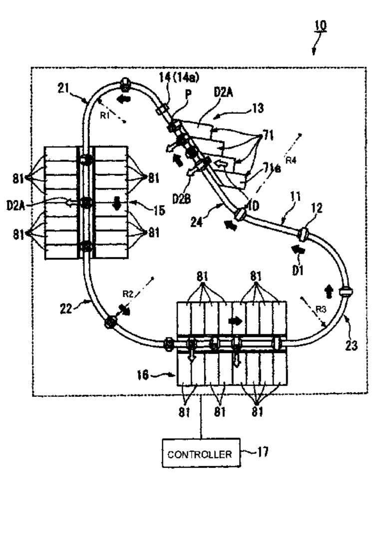
(57) **ABSTRACT**

According to one embodiment, an article sorting apparatus includes a conveyance path extending in a first conveyance direction, the conveyance path having a curve; a conveyance unit that moves along the conveyance path and conveys an article loaded on the conveyance unit in a second conveyance direction that intersects the first conveyance direction of the conveyance path; a loading portion that loads the article onto the conveyance unit; a sorting portion that sorts the article conveyed by the conveyance unit; and a controller that controls movement of the conveyance unit in the first conveyance direction and conveyance of the article in the second conveyance direction and controls the conveyance unit before entry of the conveyance unit into the curve such that if the curve has a curvature radius that is less than a predetermined threshold value, the position of the article on a load surface of the conveyance unit on which the article is placed is adjusted to a position that is offset from a middle position on the load surface to an inward side with respect to a radial direction of the curve.

12 Claims, 10 Drawing Sheets



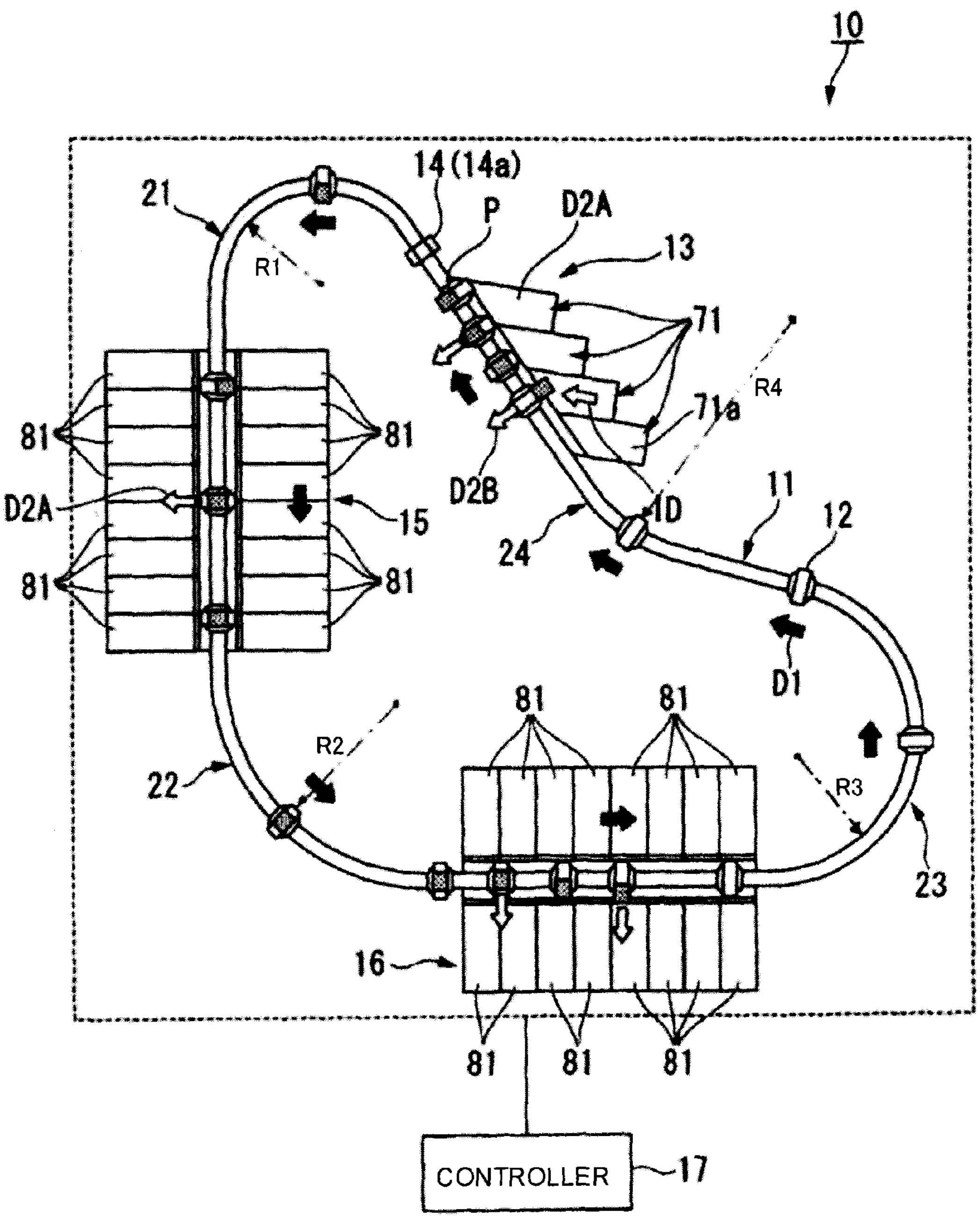

10
14 (14a)
21
P
D2A
13
R1
71
R4
71a
81
81
D2B
11
D2A
15
ID
12
24
81
81
D1
81
81
R2
22
R3
23
16
81
81
81
CONTROLLER
17

FIG. 1

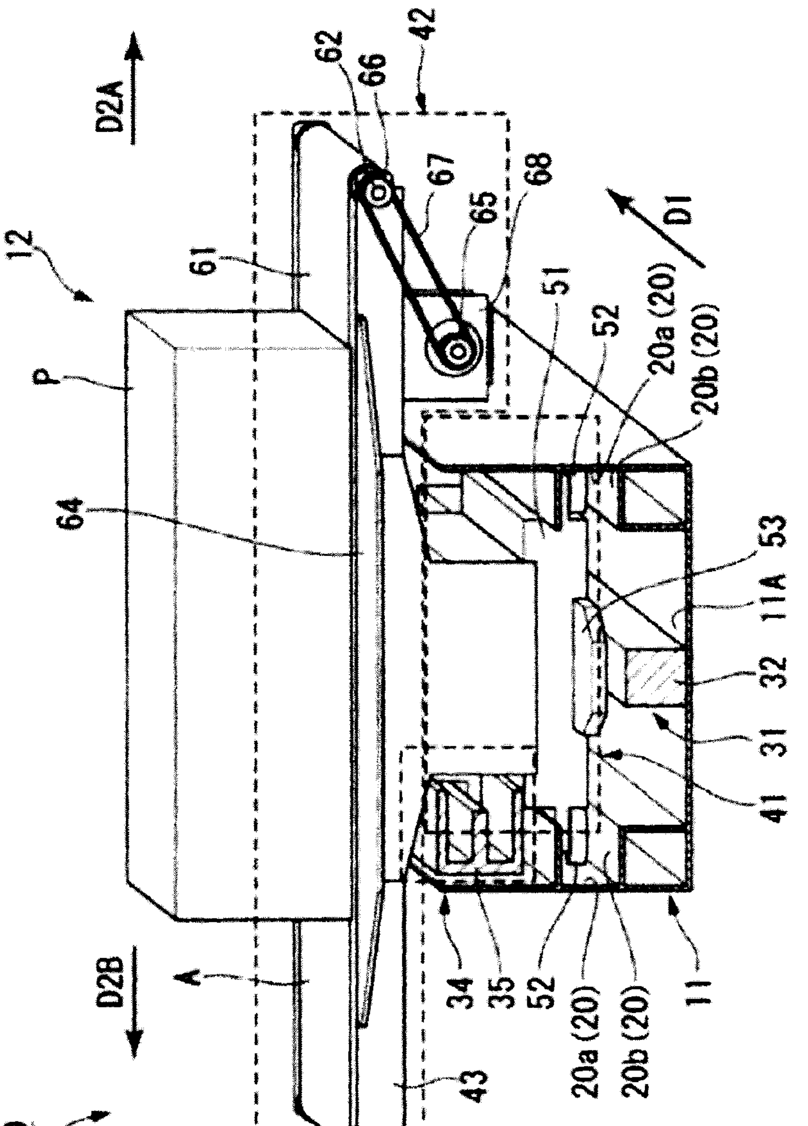

10
12
P
64
61
A
D2A
D2B
62
66
42
67
65
68
D1
51
52
20a (20)
20b (20)
53
11A
32
31
41
34
35
52
20a (20)
20b (20)
11
43
63

FIG. 2

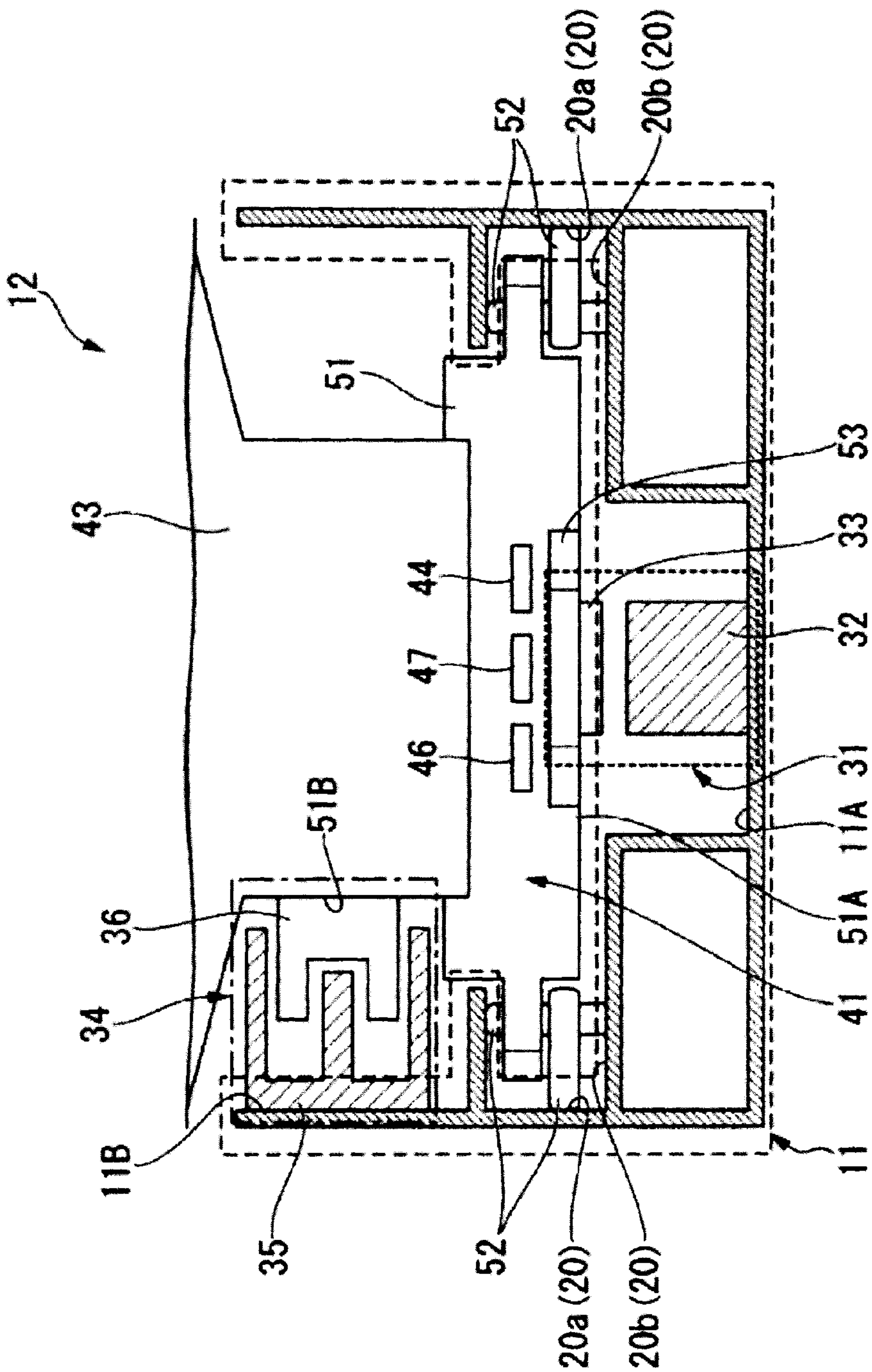

12
43
51
52
20a (20)
20b (20)
53
33
44
47
46
32
31
11A
51A
41
51B
36
34
11B
35
52
20a (20)
20b (20)
11

FIG. 3

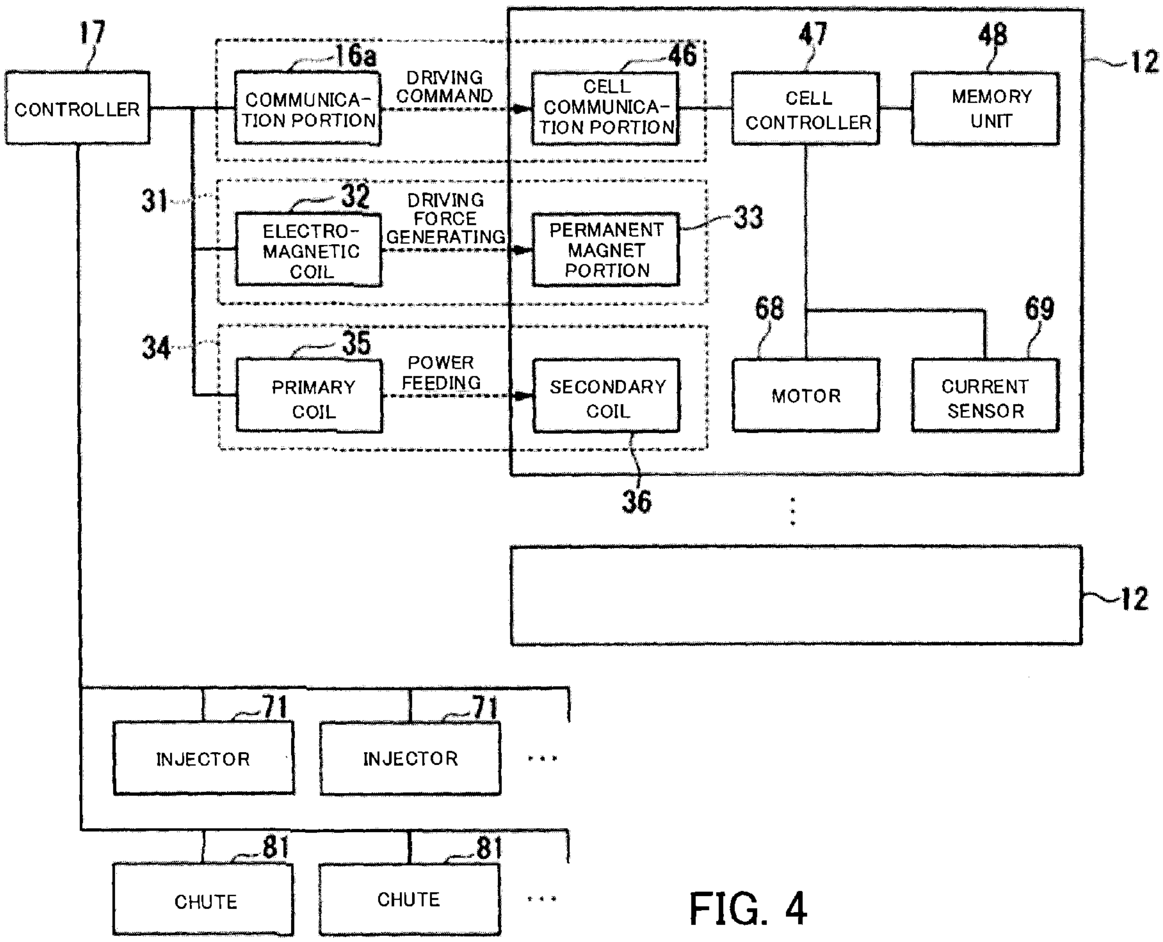

17
CONTROLLER
16a
COMMUNICA-TION PORTION
DRIVING COMMAND
46
CELL COMMUNICA-TION PORTION
47
CELL CONTROLLER
48
MEMORY UNIT
12
31
32
ELECTRO-MAGNETIC COIL
DRIVING FORCE GENERATING
PERMANENT MAGNET PORTION
33
68
69
34
35
PRIMARY COIL
POWER FEEDING
SECONDARY COIL
MOTOR
CURRENT SENSOR
36
12
71
INJECTOR
71
INJECTOR
81
CHUTE
81
CHUTE

FIG. 4

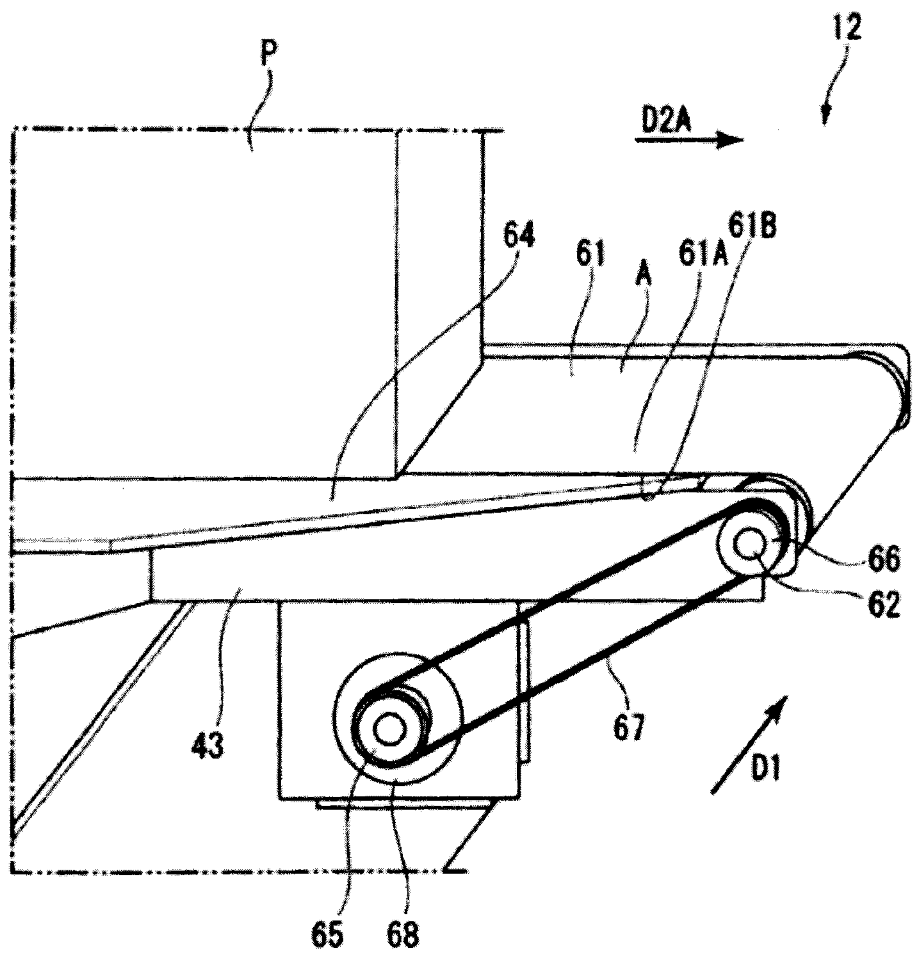
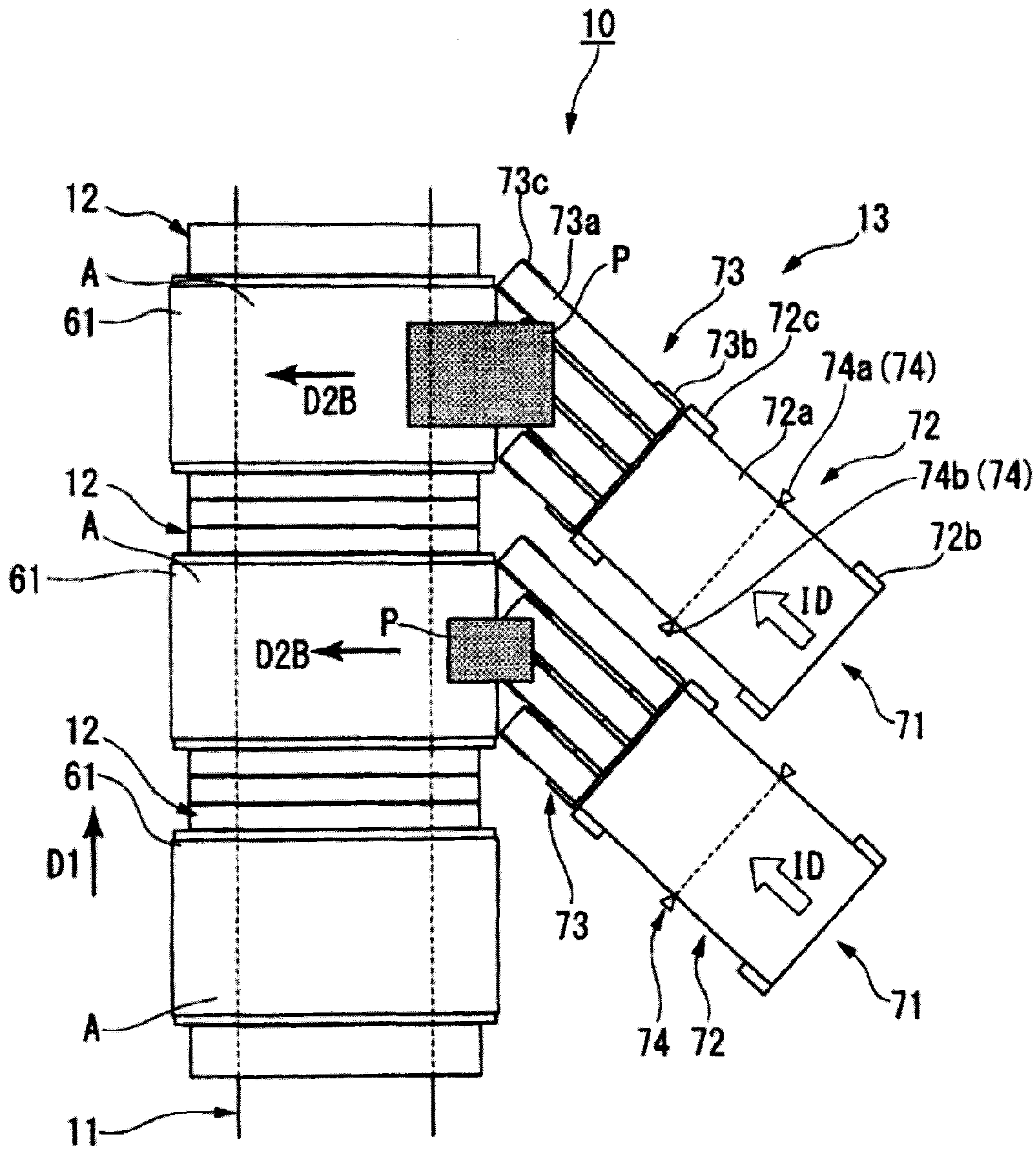
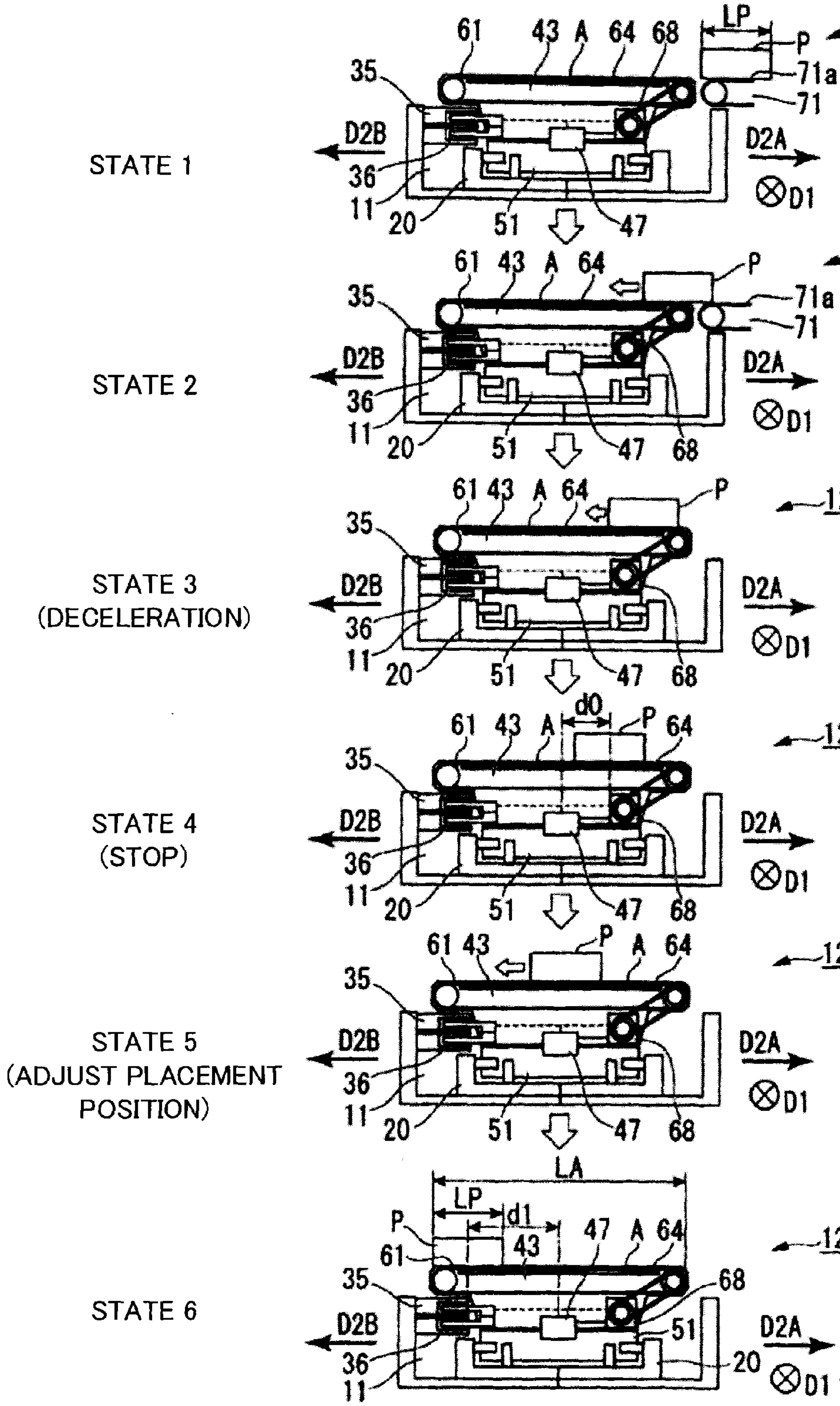


FIG. 5



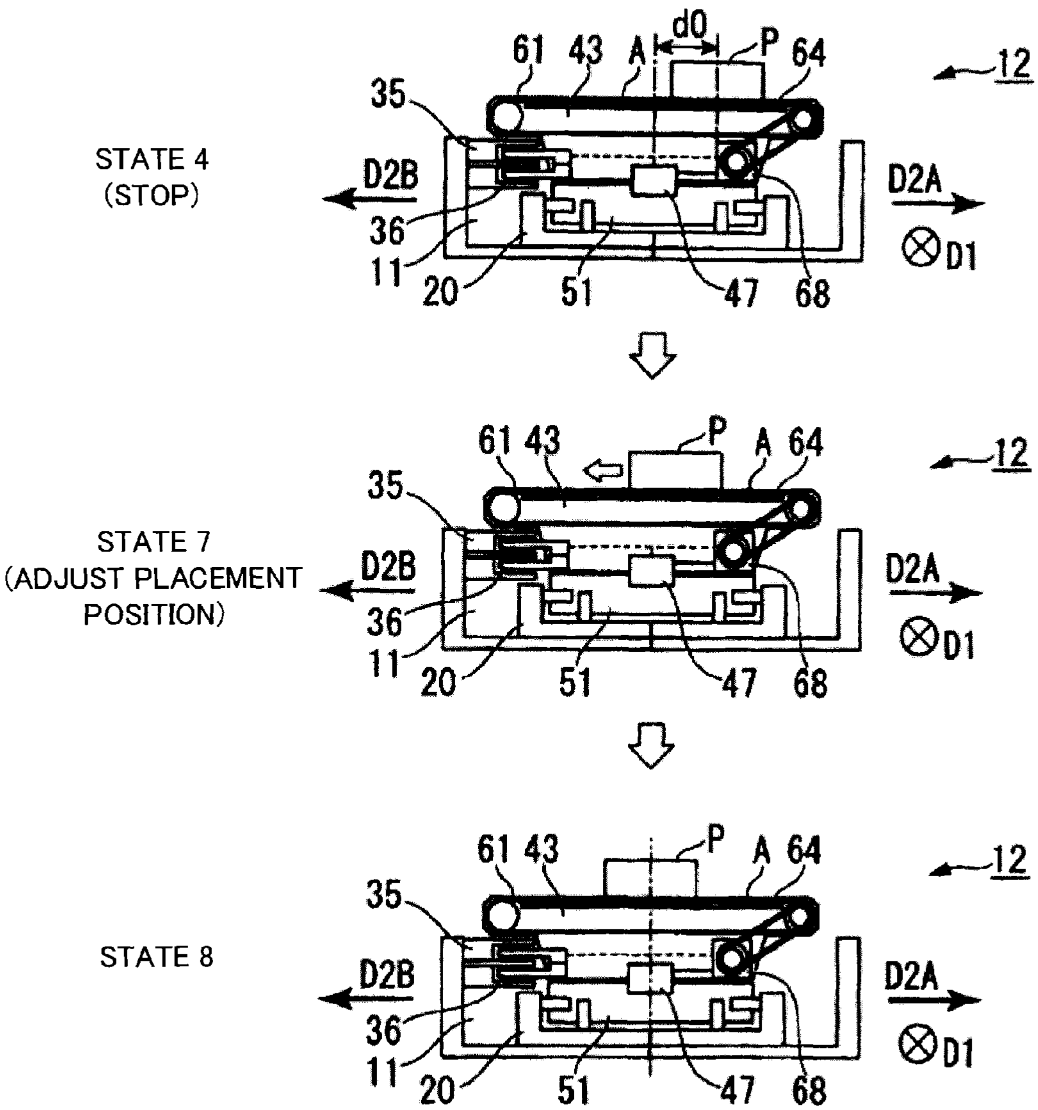
10
12
A
61
73c
73a
P
73
13
73b
72c
74a (74)
72a
72
74b (74)
72b
D2B
12
A
61
P
D2B
ID
71
12
61
D1
ID
73
A
74
72
71
11

FIG. 6



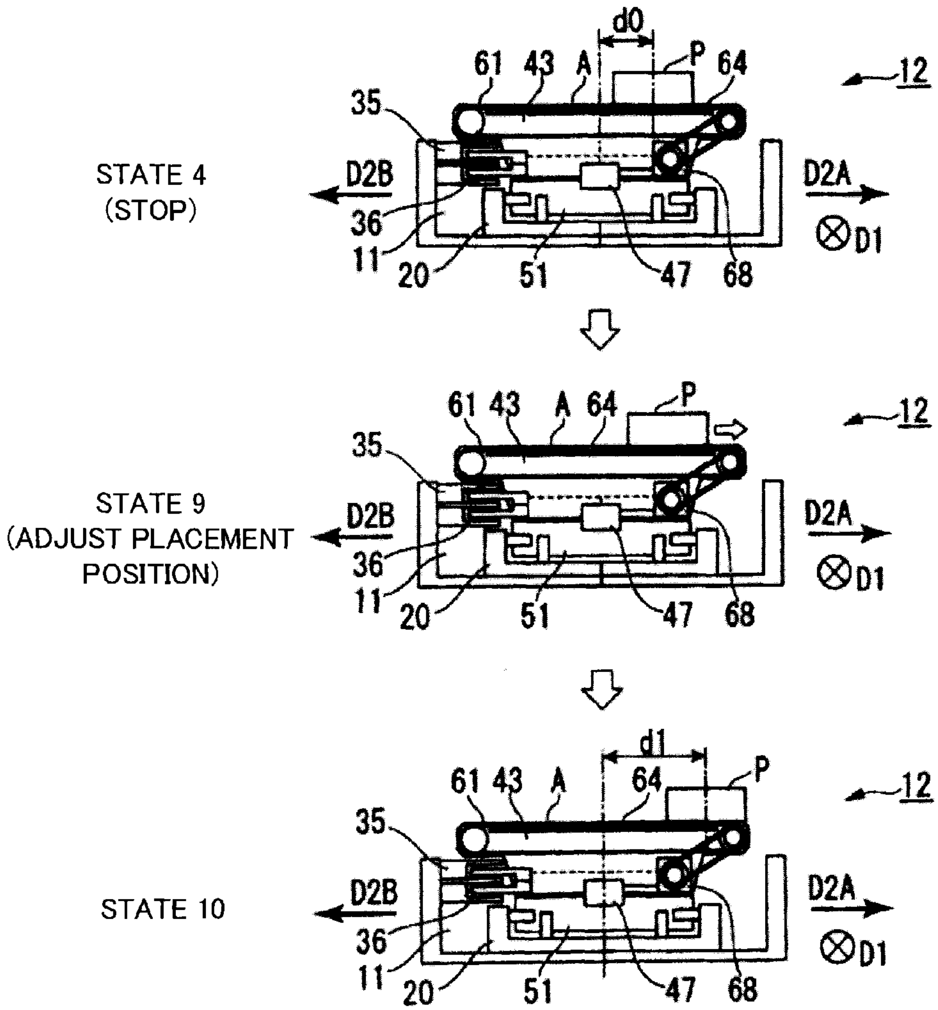
STATE 1
STATE 2
STATE 3
(DECELERATION)
STATE 4
(STOP)
STATE 5
(ADJUST PLACEMENT
POSITION)
STATE 6
LP
LA
d0
d1
P
71a
71
12
11
20
35
36
43
47
51
61
64
68
A
D2A
D2B
D1

FIG. 7



STATE 4
(STOP)
61
43
A
d0
P
64
12
35
D2B
D2A
36
11
20
51
47
68
D1
STATE 7
(ADJUST PLACEMENT
POSITION)
61 43
P
A
64
12
35
D2B
D2A
36
11
20
51
47
68
D1
STATE 8
61 43
P
A
64
12
35
D2B
D2A
36
11
20
51
47
68
D1

FIG. 8



STATE 4
(STOP)
d0
61
43
A
P
64
12
35
D2B
D2A
36
11
20
51
47
68
D1
STATE 9
(ADJUST PLACEMENT
POSITION)
STATE 10
d1

FIG. 9

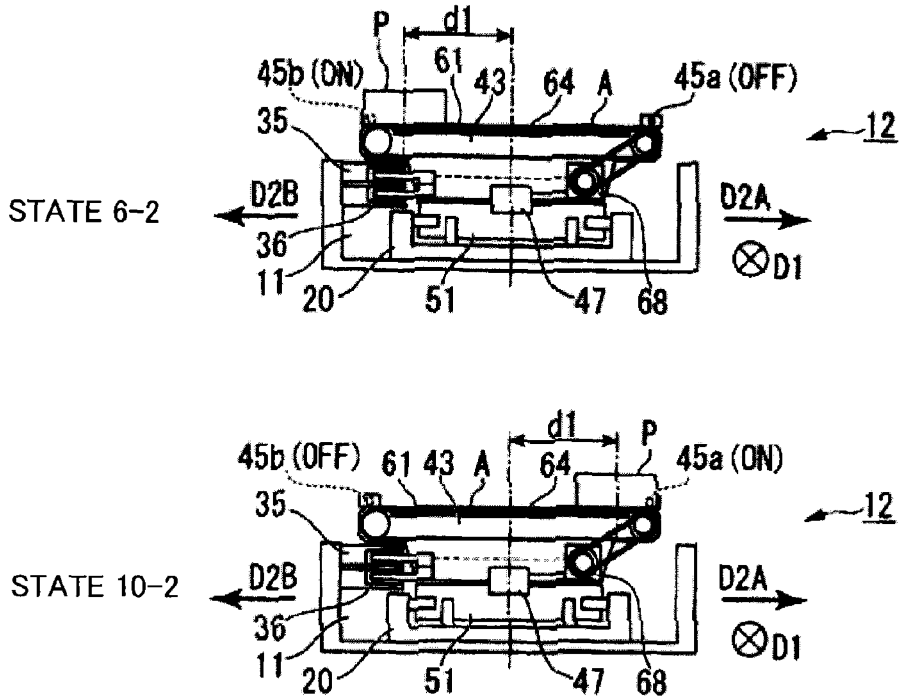

STATE 6-2
P
d1
45b (ON)
61
43
64
A
45a (OFF)
12
35
D2B
D2A
36
D1
11
20
51
47
68
STATE 10-2
45b (OFF)
45a (ON)

FIG. 10

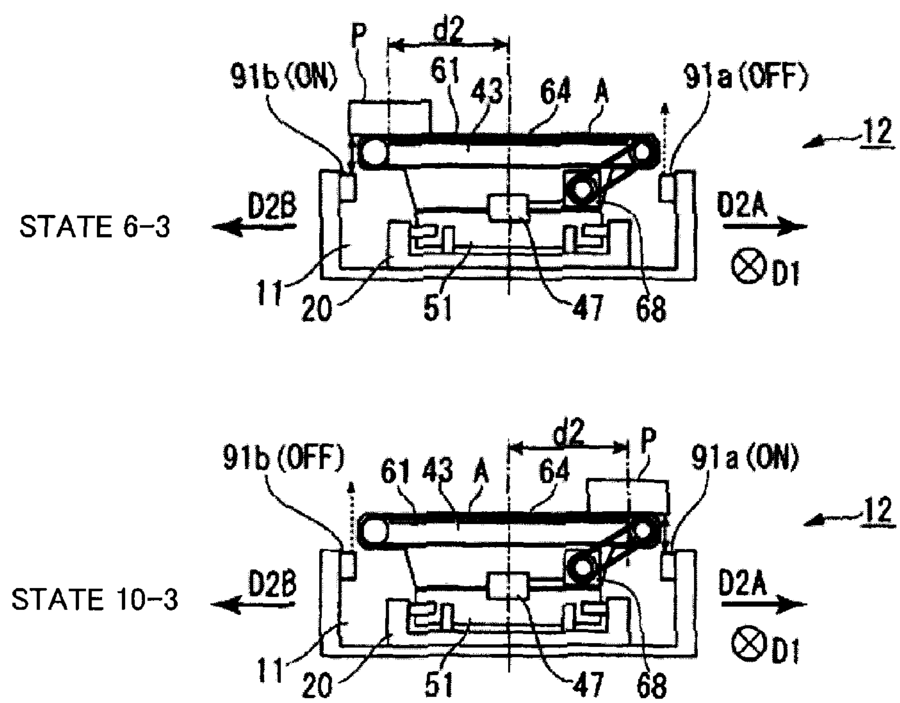

STATE 6-3
P
d2
91b (ON)
61
43
64
A
91a (OFF)
12
D2B
D2A
D1
11
20
51
47
68
STATE 10-3
91b (OFF)
91a (ON)

FIG. 11

ARTICLE SORTING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2015-096664, filed on May 11, 2015; the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to an article sorting apparatus.

BACKGROUND

Conventionally, there are cross belt sorters that convey a plurality of cells on a conveyance path and that also transfer an article in a direction orthogonal to a conveyance direction using a belt mechanism that is provided in each of the plurality of cells. The cross belt sorters convey each cell on which an article is loaded on a belt of its belt mechanism and transfer the article to a chute corresponding to a sorting destination of the article by driving the belt when the cell is adjacent to that chute. However, with priority given to prevention of an article from sliding off the belt during conveyance of each cell, it is difficult to reduce the radius of a curve of the conveyance path and to increase the conveyance speed, and thus there is a possibility that a reduction in size of the apparatus and an increase in processing speed thereof cannot be realized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view schematically showing the configuration of an article sorting apparatus according to an embodiment;

FIG. **2** is a perspective view schematically showing the configuration of a conveyor cell of the article sorting apparatus according to the embodiment;

FIG. **3** is a cross-sectional view schematically showing the configuration of a portion of the conveyor cell of the article sorting apparatus according to the embodiment;

FIG. **4** is a block diagram showing a portion of the functional configuration of the article sorting apparatus according to the embodiment;

FIG. **5** is a perspective view schematically showing the configuration of a portion of the conveyor cell of the article sorting apparatus according to the embodiment;

FIG. **6** is a plan view schematically showing the configuration of a loading portion and some of conveyor cells of the article sorting apparatus according to the embodiment;

FIG. **7** shows side views illustrating changes from State **1** to State **6** that are caused by an example of the operation of the article sorting apparatus according to the embodiment;

FIG. **8** shows side views illustrating changes in State **4**, State **7**, and State **8** that substitute for the changes from State **4** to State **6** shown in FIG. **7**;

FIG. **9** shows side views illustrating changes in State **4**, State **9**, and State **10** that substitute for the changes from State **4** to State **6** shown in FIG. **7**;

FIG. **10** shows side views illustrating State **6-2** and State **10-2** that are created by an example of the operation of an article sorting apparatus according to a first modification of the embodiment;

FIG. **11** shows side views illustrating State **6-3** and State **10-3** that are created by an example of the operation of an article sorting apparatus according to a second modification of the embodiment.

DETAILED DESCRIPTION

Hereinafter, an article sorting apparatus according to an embodiment will be described with reference to the drawings.

As shown in FIG. **1**, an article sorting apparatus **10** according to the embodiment includes a conveyance path **11**, and a plurality of conveyor cells **12**, as well as a loading portion **13**, an article position acquisition portion **14**, a first sorting portion **15**, and a second sorting portion **16**, these portions being disposed along the conveyance path **11**, and a controller **17**.

The conveyance path **11** forms a circulation (cyclic) path that guides each of the plurality of conveyor cells **12**. The conveyance path **11** guides each conveyor cell **12** to the loading portion **13**, the article position acquisition portion **14**, the first sorting portion **15**, and the second sorting portion **16**, sequentially, along the circulation (cyclic) path. The conveyance path **11** has a first curve **21**, a second curve **22**, a third curve **23**, and a fourth curve **24**, sequentially, along a first conveyance direction D**1** (i.e., counterclockwise conveyance direction shown in FIG. **1**). The first curve **21** is provided between the loading portion **13** and the first sorting portion **15**. The second curve **22** is provided between the first sorting portion **15** and the second sorting portion **16**. The third curve **23** and the fourth curve **24** are provided between the second sorting portion **16** and the loading portion **13**.

The first curve **21**, the second curve **22**, and the third curve **23** are each formed to have a left-hand curve shape that curves left as viewed in a direction of entry into the curve. The fourth curve **24** is formed to have a right-hand curve shape that curves right as viewed in the direction of entry into the curve. The first curve **21** is formed to have a curvature radius R**1** that is less than a first threshold value. The second curve **22** is formed to have a curvature radius R**2** that is not less than the first threshold value and not more than a second threshold value, the second threshold value being larger than the first threshold value. The third curve **23** is formed to have a curvature radius R**3** that is less than the first threshold value. The fourth curve **24** is formed to have a curvature radius R**4** that is larger than the second threshold value. As shown in FIGS. **2** and **3**, the conveyance path **11** is provided with guide walls **20** (e.g., first guide wall **20*a*** and second guide wall **20*b***) that come into contact with guide rollers **52** of each conveyor cell **12**, which will be described later, and thus guide the course of the guide rollers **52**.

The conveyance path **11** and the plurality of conveyor cells **12** are provided with a linear synchronous motor **31** that drives each conveyor cell **12** along the conveyance path **11**. The linear synchronous motor **31** includes, for example, an electromagnetic coil **32** that is provided along the entire length of the conveyance path **11** and that serves as a stator, and a permanent magnet array **33** that is provided in each of the plurality of conveyor cells **12** and that serves as a mover. The linear synchronous motor **31** produces a driving force (conveying force) in the first conveyance direction D**1** in the permanent magnet array **33** using the electric current flowing through the electromagnetic coil **32**. The state of the electric current flowing through the electromagnetic coil **32** is controlled by the controller **17**, and thus the linear synchronous motor **31** conveys each conveyor cell **12** at any desired speed and acceleration by means of the conveying force acting on the permanent magnet array **33**.

The conveyance path **11** and the plurality of conveyor cells **12** are provided with a noncontact feeding portion **34** that feeds power from the conveyance path **11** to each conveyor cell **12**. The noncontact feeding portion **34** includes, for example, a primary coil **35** that is provided over the entire length of the conveyance path **11** and a secondary coil **36** that is provided in each of the plurality of conveyor cells **12**. The noncontact feeding portion **34** feeds power from the conveyance path **11** to each conveyor cell **12** by electromagnetic induction between the primary coil **35** and the secondary coil **36**.

The plurality of conveyor cells **12** that are moved along the conveyance path **11** are arranged in a line in the first conveyance direction D**1**. The conveyor cells **12** that are adjacent to each other on the front side and the rear side in the first conveyance direction D**1** are coupled to each other, for example. Coupling the conveyor cells **12** to each other enables the driving force to be transmitted to all the conveyor cells **12**. Each of the plurality of conveyor cells **12** includes a chassis portion **41**, a cross belt mechanism **42**, a frame portion **43** to which the chassis portion **41** and the cross belt mechanism **42** are fixed, a battery **44**, a cell communication portion **46**, and a cell controller **47**. As shown in FIG. **4**, each of the plurality of conveyor cells **12** includes a memory unit **48**.

As shown in FIGS. **2** and **3**, the chassis portion **41** includes a chassis **51** serving as the base for the entire conveyor cell **12**, two guide rollers **52** supported by the chassis **51**, and connection mechanisms **53**. With respect to the chassis **51**, for example, the permanent magnet array **33** of the linear synchronous motor **31** is fixed to an under surface **51**A of the chassis **51** that opposes a bottom face **11**A of the conveyance path **11**. Thus, the chassis **51** allows the permanent magnet array **33** to be disposed opposing the electromagnetic coil **32** that is provided on the bottom face **11**A of the conveyance path **11**. With respect to the chassis **51**, for example, the secondary coil **36** of the noncontact feeding portion **34** is fixed to a side face **51**B of the chassis **51** that opposes an inner wall surface **11**B of the conveyance path **11**. Thus, the chassis **51** allows the secondary coil **36** to be disposed opposing the primary coil **35** that is provided on the inner wall surface **11**B of the conveyance path **11**.

Each of the two guide rollers **52** has a rotation shaft (not shown) that is supported by the chassis **51**. When the conveyor cell **12** is conveyed along the conveyance path **11**, each guide roller **52** rotates about its rotation shaft while coming into contact with the guide wall **20** (i.e., first guide wall **20***a* and second guide wall **20***b*) of the conveyance path **11**. Thus, the guide rollers **52** guide the conveyor cell **12** to the course that is guided by the guide walls **20** of the conveyance path **11**.

The connection mechanisms **53** are respectively fixed to a front portion and a rear portion of the chassis **51**. The connection mechanisms **53** of each conveyor cell **12** are coupled to the corresponding connection mechanisms **53** of other conveyor cells **12** that are adjacent to that conveyor cell **12** respectively on the front side and the rear side thereof in the first conveyance direction D**1** so as to be rotatable about at least a vertical rotation shaft (not shown). Thus, the conveyor cells **12** that are adjacent to each other on the front side and the rear side in the first conveyance direction D**1** are coupled to each other by their connection mechanisms **53** without obstructing each other's operation.

The cross belt mechanism **42** is fixed to the chassis portion **41** by the frame portion **43** made of metal, for example. The cross belt mechanism **42** conveys an article P loaded thereon in a second conveyance direction (e.g., first transfer direction D**2**A or second transfer direction D**2**B that are opposite to each other) that is orthogonal to the first conveyance direction D**1**. The first transfer direction D**2**A is, for example, the rightward direction of the conveyor cell **12** as viewed in the first conveyance direction D**1**. The second transfer direction D**2** is, for example, the leftward direction of the conveyor cell **12** as viewed in the first conveyance direction D**1**. The cross belt mechanism **42** includes a cross belt **61**, a driving roller **62**, a driven roller **63**, a belt support board **64**, a motor-side toothed pulley **65**, a roller-side toothed pulley **66**, a timing belt **67**, and a motor **68**. As shown in FIG. **4**, the cross belt mechanism **42** includes a current sensor **69**.

The cross belt **61** is a tubular endless belt formed of a flat belt, for example. The surface of the cross belt **61** is coated with a synthetic resin such as polyvinyl chloride, polyurethane, or synthetic rubber, for example. As shown in FIG. **2**, the cross belt **61** is stretched between the driving roller **62** and the driven roller **63**. The cross belt **61** is rotated by a rotational driving force of the driving roller **62**, thereby rotating the driven roller **63**. The driving roller **62** and the driven roller **63** are arranged parallel to each other with a predetermined distance left therebetween in the left-right direction (i.e., first transfer direction D**2**A and second transfer direction D**2**B) of the conveyor cell **12**. As shown in FIGS. **2** and **5**, an upper surface of an outside surface **61**A of the cross belt **61**, a normal to that upper surface extending in the vertically upward direction, forms a load surface A on which an article P is placed. The belt support board **64** supports a portion of an internal surface **61**B of the cross belt **61**, the portion constituting a back face of the load surface A. Thus, the belt support board **64** prevents bending of the cross belt **61** against the weights of the cross belt **61** and the article P placed on the load surface A.

The driving roller **62** and the driven roller **63** each have a rotation shaft (not shown) that is supported by the frame portion **43**. The respective rotation shafts of the driving roller **62** and the driven roller **63** are arranged extending in the front-rear direction (i.e., first conveyance direction D**1**) of each conveyor cell **12** and parallel to each other with a predetermined distance left therebetween in the left-right direction (i.e., first transfer direction D**2**A and second transfer direction D**2**B) of each conveyor cell **12**. The motor-side toothed pulley **65** is coaxially connected to the motor **68**. The roller-side toothed pulley **66** is coaxially connected to the driving roller **62**. The timing belt **67** is a toothed endless belt meshing with the motor-side toothed pulley **65** and the roller-side toothed pulley **66**. The timing belt **67** is stretched between the motor-side toothed pulley **65** and the roller-side toothed pulley **66**. The timing belt **67** is rotated by a rotational driving force of the motor-side toothed pulley **65**, thereby rotating the roller-side toothed pulley **66**.

The motor **68** is a servo motor that is controlled by the cell controller **47**. The motor **68** is coaxially connected to the motor-side toothed pulley **65**. The motor **68** produces a rotational driving force using power that is fed from the noncontact feeding portion **34**, and thus rotates the motor-side toothed pulley **65**. The timing belt **67** transmits the rotation of the motor-side toothed pulley **65** to the roller-side toothed pulley **66**. The roller-side toothed pulley **66** drives and rotates the driving roller **62**. The driving roller **62** transmits the rotation to the cross belt **61** and the driven roller **63**. Thus, the cross belt **61** is driven in the left-right direction of each conveyor cell **12**, thereby transferring the article P placed on the load surface A in the first transfer direction D2A and the second transfer direction D2B. As shown in FIG. **4**, the current sensor **69** detects the electric current flowing through the motor **68**. For example, the current sensor **69** detects a regenerative current flowing through the motor **68** during deceleration of the motor **68**.

As shown in FIG. **3**, the battery **44** is provided in the chassis portion **41**. The battery **44** stores power that is fed from the noncontact feeding portion **34**.

The cell communication portion **46** is provided in the chassis portion **41**. The cell communication portion **46** sends/receives various types of information by contactless communication (e.g., infrared communication, wireless communication, or the like) between the controller **17** and the cell controller **47**. The cell communication portion **46** receives a driving command from a communication portion **16***a*. The cell communication portion **46** is operated by power that is fed from the battery **44**.

The cell controller **47** may be, for example, a PLC (programmable logic controller), a control board, or the like. The cell controller **47** is fixed to the chassis portion **41**. The cell controller **47** is operated by power that is fed from the battery **44**. The cell controller **47** controls driving of the motor **68** in accordance with a control instruction that is output from the controller **17**. The memory unit **48** is fixed to the chassis portion **41**. The memory unit **48** stores various data. For example, the memory unit **48** stores data on a driving pattern that is used by the cell controller **47** when controlling driving of the motor **68**.

As shown in FIGS. **1** and **6**, the loading portion **13** loads articles P onto the plurality of conveyor cells **12**. For example, the loading portion **13** is disposed on an outward side of the conveyance path **11**, that is, on the right side of the conveyance path **11** (i.e., the first transfer direction D2A side of the conveyor cells **12**) as viewed in the first conveyance direction D**1** if the first conveyance direction D**1** is a counterclockwise conveyance direction. The loading portion **13** includes at least one or more (e.g., a plurality of) injectors **71**. Each of the injectors **71** includes a first conveyance portion **72** and a second conveyance portion **73** that are arranged in a transfer direction ID intersecting the first conveyance direction D**1** of the conveyance path **11** at a predetermined acute angle.

The first conveyance portion **72** includes a first transfer belt **72***a* that is driven in the transfer direction ID as well as a first driving roller **72***b* and a first driven roller **72***c* between which the first transfer belt **72***a* is stretched. The first driving roller **72***b* and the first driven roller **72***c* are arranged parallel to each other with a predetermined distance left therebetween in the transfer direction ID. The first transfer belt **72***a* is rotated by a rotational driving force of the first driving roller **72***b*, thereby rotating the first driven roller **72***c*. The second conveyance portion **73** includes a plurality of second transfer belts **73***a* that are driven in the transfer direction ID. Each of the second transfer belts **73***a* is formed such that its width (belt width in a direction orthogonal to the transfer direction ID) is smaller than the width of the first transfer belt **72***a*. The plurality of second transfer belts **73***a* are arranged at predetermined intervals in the width direction (i.e., the direction orthogonal to the transfer direction ID). Each of the second transfer belts **73***a* is stretched between a second driving roller **73***b* and a second driven roller **73***c* that are arranged parallel to each other with a predetermined distance left therebetween in the transfer direction ID. Each second transfer belt **73***a* is rotated by a rotational driving force of the second driving roller **73***b*, thereby rotating the second driven roller **73***c*. Thus, each injector **71** successively transfers articles P in the transfer direction ID, which intersects the first conveyance direction D**1** of the conveyance path **11** at a predetermined acute angle, from the first conveyance portion **72** and the second conveyance portion **73** to desired conveyor cells **12**.

Each injector **71** includes an article length sensor **74** that is disposed in the first conveyance portion **72**. The article length sensor **74** includes a light emitting portion **74***a* and a light receiving portion **74***b* that are arranged opposing each other so as to cross over the first conveyance portion **72**. Irradiation light that is output from the light emitting portion **74***a* is received by the light receiving portion **74***b* if no article P is present on its optical axis. The article length sensor **74** outputs an ON signal if an article P is present on the optical axis of the irradiation light that is output from the light emitting portion **74***a* and interrupts the receipt of the irradiation light by the light receiving portion **74***b*. The article length sensor **74** outputs an OFF signal if no article P is present on the optical axis of the irradiation light that is output from the light emitting portion **74***a*, and the light receiving portion **74***b* continues receiving the irradiation light. The article length sensor **74** detects an ON time from the occurrence of switching from the OFF signal to the ON signal to the occurrence of switching from the ON signal to the OFF signal. The article length sensor **74** detects the length of an article P from the detected ON time and a previously known transfer speed of articles P in each injector **71**. The article length sensor **74** outputs information on the detected length of the article P to the controller **17**.

The article position acquisition portion **14** may be, for example, a high-speed camera that is disposed above the conveyance path **11**. The article position acquisition portion **14** detects the position of an article P on the load surface A of each conveyor cell **12** based on image data obtained by imaging that load surface A. For example, the article position acquisition portion **14** detects the position of the article P on the load surface A with respect to the second conveyance direction, and sends information on the detected position to the controller **17**. For example, the article position acquisition portion **14** detects the distance d**0** between the middle position of the load surface A with respect to the second conveyance direction and the center position of the article P. The article position acquisition portion **14** detects the distance d**0** between the middle position of the load surface A and the center position of the article P immediately after the loading portion **13**, for example, thereby detecting an offset (=distance d**0**) of the loading position of the article P that is loaded onto the load surface A in the loading portion **13**.

The article position acquisition portion **14** includes an information acquisition portion **14***a* that is configured integrally therewith, for example. The information acquisition portion **14***a* includes, for example, an optical character recognition (OCR) device, a code reader that reads a one-dimensional code, a two-dimensional code, or the like, or an RF reader that communicates with an IC tag attached to or incorporated in the article P. The information acquisition portion **14***a* acquires information given to the article P that is loaded on each conveyor cell **12** and sends the acquired information to the controller **17**.

The first sorting portion **15** and the second sorting portion **16** each receive articles P that are individually released from the plurality of conveyor cells **12**. Each of the first sorting portion **15** and the second sorting portion **16** includes a plurality of chutes **81** for different classification destinations, the chutes being arranged along the first conveyance direction D**1** of the conveyance path **11**. For example, each of the first sorting portion **15** and the second sorting portion **16** includes a plurality of chutes **81** on the inward side and the outward side of the conveyance path **11**, that is, on the right side and the left side of the conveyance path **11** as viewed in the first conveyance direction D**1** when the first conveyance direction D**1** is the counterclockwise conveyance direction.

The controller **17** performs overall control of the article sorting apparatus **10**. The controller **17** controls the state of the electric current flowing through the electromagnetic coil **32** of the linear synchronous motor **31**, thereby controlling acceleration, deceleration, stop (emergency stop etc.), and the like of each conveyor cell **12**. The controller **17** stores layout information (e.g., positions of the first to fourth curves **21** to **24**, the loading portion **13**, the first sorting portion **15**, and the second sorting portion **16** on the conveyance path **11**, directions and curvature radii of the first to fourth curves **21** to **24**, and the like) of the article sorting apparatus **10** in advance. The controller **17** manages information on the article P (e.g., classification destination (sorting destination), weight, and the like of the article P) that is acquired by the information acquisition portion **14***a* and various types of information regarding the article P, such as the length of the article P that is detected by the article length sensor **74**.

The controller **17** communicates with each of the loading portion **13**, the article position acquisition portion **14**, the first sorting portion **15**, and the second sorting portion **16** in a wired manner or in a wireless manner to send/receive various types of information. The controller **17** controls the operation of each of the loading portion **13**, the article position acquisition portion **14**, the first sorting portion **15**, and the second sorting portion **16** by sending control instructions to these portions. The controller **17** sends/receives various types of information by performing noncontact communication with the respective cell controllers **47** of the plurality of conveyor cells **12**. The controller **17** sends a control instruction to each cell controller **47**, the control instruction instructing the control operation of the cell controller **47**.

The controller **17** synchronizes the acceleration/deceleration driving and stopping operations of the cross belt **61** by the motor **68** of each conveyor cell **12** with the transferring operation of an article P by each injector **71** so that the article P is delivered from the injector **71** of the loading portion **13** to the corresponding conveyor cell **12**. The controller **17** sends a control instruction to the cell controller **47** of each conveyor cell **12**, the control instruction instructing execution of a series of receiving operations by acceleration/deceleration driving and stopping of the cross belt **61** by the motor **68** of the conveyor cell **12**. The controller **17** sends information on the length of the article P, which is detected by the article length sensor **74**, to the cell controller **47** of each conveyor cell **12** together with the control instruction that instructs execution of the receiving operations.

When instructed by the controller **17** to execute the receiving operations, the cell controller **47** of each conveyor cell **12** controls driving of the motor **68** using the data on the control pattern, which is stored in the memory unit **48** in advance, and the information on the length of the article P. The cell controller **47** of each conveyor cell **12** controls acceleration/deceleration driving and stopping of the motor **68**, thereby controlling the receipt and retention of the article P by the cross belt **61**. The cell controller **47** of each conveyor cell **12** controls the motor **68** such that the center position of the article P coincides with a predetermined position (e.g., middle position or the like of the load surface A with respect to the left-right direction of each conveyor cell **12**) on the load surface A and the article P is retained in this state. The cell controller **47** stores predetermined data in advance, the predetermined data indicating, for example, the correspondence relationship between the angle of rotation of the motor **68** and the amount for which the cross belt **61** is moved. The cell controller **47** moves the cross belt **61** and the article P for a desired distance by controlling the angle of rotation of the motor **68** based on the predetermined data stored therein. Thus, the loading portion **13** transfers the article P from each injector **71** onto the load surface A of each conveyor cell **12**.

The controller **17** acquires information on the article P that is loaded on the load surface A of each conveyor cell **12** by the loading portion **13** from the information acquisition portion **14***a*. The controller **17** determines the classification destination of the article P based on the information on the article P that is received from the information acquisition portion **14***a*, and selects the chute **81** corresponding to the determined classification destination from the plurality of chutes **81** of the first sorting portion **15** and the second sorting portion **16**. The controller **17** sets the timing of driving of the cross belt **61** by the motor **68** of each conveyor cell **12** (i.e., timing at which the article P is loaded into the chute **81**) such that the article P is loaded into the selected chute **81** from the conveyor cell **12**. The controller **17** sends a control instruction to the cell controller **47** of each conveyor cell **12**, the control instruction instructing the timing of driving of the cross belt **61** by the motor **68** of the conveyor cell **12**.

The cell controller **47** of each conveyor cell **12** controls driving of the motor **68** using the driving timing that is specified by the controller **17**, the data on the control pattern of the discharging operation that is stored in the memory unit **48** in advance, the information on the weight of the article P, and the like. The cell controller **47** of each conveyor cell **12** controls loading of the article P into the chute **81** by the cross belt **61**. Thus, each of the first sorting portion **15** and the second sorting portion **16** sorts the article P of each conveyor cell **12** in accordance with its classification destination corresponding to the information on the article P.

Before each conveyor cell **12** enters any curve of the conveyance path **11**, the controller **17** instructs the cell controller **47** to adjust the position of the article P on the load surface A of the conveyor cell **12** to a predetermined position in accordance with the curvature radius of that curve. In accordance with the curvature radius of the curve, the controller **17** moves the position of the article P on the load surface A to a position that is offset from the middle position in the second conveyance direction. If the curvature radius of the curve is less than a first threshold value, the controller **17** moves the article P such that the position of the article P when the conveyor cell **12** enters the curve is offset from the middle position to an inward side with respect to the radial direction of the curve by a predetermined distance d**1**. On the other hand, if the curvature radius of the curve is not less than the first threshold value, the controller **17** moves the article P such that the position of the article P at this point in time is maintained or the position of the article P is moved to the middle position on the load surface A. It should be noted that if a first curve having a curvature radius that is not less than the first threshold value is followed by a downstream second curve having a curvature radius that is less than the first threshold value, the controller **17** may move the position of the article P at (or before) the first curve to a position that is offset from the middle position on the load surface A to the inward side with respect to the radial direction by the predetermined distance d**1**.

The controller **17** sets the first threshold value with respect to the curvature radius R of a curve in accordance with the length LA of the load surface A of each conveyor cell **12** in the second conveyance direction. For example, the controller **17** sets the first threshold value with respect to the curvature radius R of a curve in correspondence with a predetermined threshold value with respect to the ratio between the curvature radius R of the curve and the length LA. The controller **17** sets the first threshold value with respect to the curvature radius R of a curve in correspondence with setting of the ratio (LA:R) between the length LA and the curvature radius R of the curve to about 1:7 to 1:10, for example.

For example, ignoring air resistance of the article P, the controller **17** sets the requirement (stationary requirement) for the article P to be stationary on the load surface A at a curve to "maximum friction force G>centrifugal force F". The controller **17** sets the maximum friction force $G=\mu Mg$ and the centrifugal force $F=Mr\omega^2=Mr(V/R)^2$ using the weight M of the article P, the conveyance speed V, and the radius of gyration "r" of the article P at the curve, as well as the coefficient μ of friction between an under surface of the article P and the load surface A, and the gravitational acceleration "g". The conveyance speed of each conveyor cell **12** in a curve is the same as the conveyance speed V at the center position thereof with respect to the second conveyance direction, and the angular speed ω is $\omega=V/R$. That is to say, each conveyor cell **12** passing through the curve performs a rotational motion about the center of the curve at the angular speed ω. The article P that is stationary on the load surface A of each conveyor cell **12** also performs a rotational motion at the angular speed ω like the conveyor cell **12**. While the angular speed ω of the article P depends on the curvature radius R of the curve, the centrifugal force F acting on the article P depends on the radius of gyration "r" of the article P. Thus, the stationary requirement becomes $\mu g>r(V/R)^2$, and does no longer depend on the weight M of the article P. When the angular speed ω, the friction coefficient μ, and the gravitational acceleration "g" are respectively constants, the controller **17** takes into account that the smaller the radius of gyration "r" of the article P at the curve, the more easily the article P becomes stationary on the load surface A due to a reduction in the centrifugal force F.

If the ratio between the curvature radius R and the length LA is less than a predetermined threshold value, the controller **17** takes into account that reducing the centrifugal force F by reducing the radius of gyration "r" by moving the article P on the load surface A is effective for fulfillment of the stationary requirement. On the other hand, if the ratio between the curvature radius R and the length LA is not less than the predetermined threshold value, the controller **17** takes into account that even when the radius of gyration "r" is reduced by moving the article P on the load surface A, the centrifugal force F is reduced only slightly.

Before a given conveyor cell **12** enters the first sorting portion **15** and the second sorting portion **16** on the conveyance path **11**, the controller **17** moves the position of the article P on the load surface A of the conveyor cell **12** to a position that is offset from the middle position in the second conveyance direction. The controller **17** moves the article P such that when the conveyor cell **12** enters each of the first sorting portion **15** and the second sorting portion **16**, the article P is located at a position that is offset from the middle position to a side that is closer to the chute **81** corresponding to the classification destination of the article P by a predetermined distance d**1** in the second conveyance direction.

With respect to the movement of the article P on the load surface A that is instructed by the controller **17**, the cell controller **47** of the conveyor cell **12** moves the article P by the predetermined distance d**1** that is set in advance, until an end portion of the article P comes into contact with a first end portion or a second end portion with respect to the second conveyance direction. In accordance with a control instruction from the controller **17**, each cell controller **47** moves the article P on the load surface A when the loading portion **13** loads the article P onto the conveyor cell **12** or immediately after the conveyor cell **12** passes through a curve that is located upward of a target curve.

Hereinafter, the operation of the article sorting apparatus **10** according to the above-described embodiment will be described. In the following description, the operations over time of a single conveyor cell **12** of the plurality of conveyor cells **12** circulating through the conveyance path **11** shown in FIG. **1**, for example, will be described with reference to FIG. **7**. The conveyor cells **12** other than the single conveyor cell **12** described below perform the same operations as the single conveyor cell **12** described below.

In the following description, each conveyor cell **12** moves along the conveyance path **11** at a constant conveyance speed V (e.g., a predetermined speed within a range of about 2.0 to 4.0 m/s, etc.). The article P loaded on each conveyor cell **12** is sorted to any chute **81** of the first sorting portion **15** and the second sorting portion **16**.

When a conveyor cell **12** on which no article P is loaded enters the loading portion **13**, the controller **17** instructs the loading portion **13** to deliver an article P to that conveyor cell **12**. The controller **17** instructs the cell controller **47** of that conveyor cell **12** to control driving of the cross belt **61** by the motor **68** in synchronization with transfer of the article P by a certain injector **71** of the loading portion **13**. The controller **17** instructs the cell controller **47** to draw the article P from the injector **71** onto the load surface A of the cross belt **61** and to move the article P on the load surface A as appropriate for the first curve **21**.

The loading portion **13** loads the article P onto the conveyor cell **12** in accordance with the control instruction from the controller **17**. The injector **71** of the loading portion **13** transfers the article P toward the conveyor cell **12** by driving of the transfer belt **71***a*. The injector **71** sets a component in the first conveyance direction D**1** of the transfer speed of the article P to be equal to the speed of the conveyor cell **12** in the first conveyance direction D**1** (State **1**). In State **1**, the article length sensor **74** detects the length LP of the article P from the ON time between the occurrence of switching from an OFF signal to an ON signal and the occurrence of switching from the ON signal to an OFF signal as well as the previously known transfer speed of articles P in each injector **71**. The article length sensor **74** outputs information on the detected length LP of the article P to the controller **17**.

The cell controller **47** of the conveyor cell **12** draws the article P from the injector **71** onto the load surface A of the cross belt **61** in accordance with the instruction from the controller **17**. The cell controller **47** sets the driving speed of the load surface A of the cross belt **61** to be equal to a second conveyance direction component of the speed of transfer of the article P by the injector **71**. The loading portion **13** is disposed on the right side of the conveyance path **11** (on the first transfer direction D**2**A side of the conveyor cell **12**) as viewed in the first conveyance direction D**1**. Thus, the cell controller **47** drives the load surface A of the cross belt **61** in the second transfer direction D**2**B and sets the driving speed of the cross belt **61** to be equal to the component in the second transfer direction D2B of the speed of transfer of the article P by the injector **71** (State **2**).

It should be noted that if the loading portion **13** is disposed on the left side of the conveyance path **11** (on the second transfer direction D2B side of the conveyor cell **12**) as viewed in the first conveyance direction D1, the cell controller **47** drives the load surface A of the cross belt **61** in the first transfer direction D2A. Thus, the cell controller **47** sets the driving speed of the cross belt **61** in the first transfer direction D2A to be equal to the component in the first transfer direction D2A of the speed of transfer of the article P by the injector **71**.

Next, the cell controller **47** performs deceleration control of the cross belt **61** such that the article P stops at the middle position on the load surface A, based on the data on the control pattern with respect to an article P having a typical weight, which is stored in the memory unit **48** in advance (State **3**). The controller **17** decelerates the first conveyance direction component of the transfer speed of the article P of the injector **71** similarly to the driving speed of the load surface A of the cross belt **61**. The typical weight of articles P may be a predetermined weight between 5 and 20 kg, for example.

If a large difference is present between the typical weight of articles P that is stored in the memory unit **48** in advance and the weight of an article P that is actually transferred, the article P may stop at a loading position that is offset from the middle position of the load surface A due to a variation in the behavior, such as rising and falling, of the rotation speed of the motor **68**. If an inertial force that is larger than the maximum friction force of the article P on the load surface A is applied due to acceleration/deceleration of the motor **68**, the article P slides on the load surface A, and thus the article P may stop at a loading position that is offset from the middle position of the load surface A. In the following description, it is assumed that the distance d**0** between the middle position of the load surface A and the center position of the article P is the offset d**0** of the loading position of the article P (State **4**). It should be noted that the position at which the article P loaded from the loading portion **13** onto the load surface A stops is referred to as the "loading position".

With respect to each conveyor cell **12** that is conveyed from the loading portion **13**, the controller **17** detects the offset d**0** of the loading position of the article P using the article position acquisition portion **14**. The controller **17** instructs the cell controller **47** to adjust the placement position of the article P on the load surface A based on the offset d**0** of the loading position of the article P, which is detected by the article position acquisition portion **14**, and the curvature radius of the closest curve, that is, the curvature radius R**1** of the first curve **21**. The cell controller **47** controls driving of the cross belt **61** so as to adjust the placement position of the article P on the load surface A in accordance with the instruction from the controller **17** (State **5**). It should be noted that the position to which the article P is moved on the load surface after loading of the article P is referred to as the "placement position".

Since the curvature radius R**1** of the first curve **21** is less than the first threshold value, the cell controller **47** drives the cross belt **61** such that the center position of the article P is adjusted to a position that is offset from the middle position of the load surface A to the inward side with respect to the radial direction of the first curve **21** by the predetermined distance d**1**. The predetermined distance d**1** is, for example, d**1**=(LA−LP)/2 based on the previously known length LA of the load surface A in the second conveyance direction and the detected length LP of the article P. As shown in State **4**, if the offset d**0** of the loading position is formed on the near side of the middle position of the load surface A with respect to the driving direction (second transfer direction D2B) of the cross belt **61**, the cell controller **47** moves the article P for the sum (=d**1**+d**0**) of the predetermined distance d**1** and the offset d**0** of the loading position. If the offset d**0** of the loading position is formed on the far side of the middle position of the load surface A with respect to the driving direction (second transfer direction D2B) of the cross belt **61**, the cell controller **47** moves the article P for the difference (=d**1**−d**0**) between the predetermined distance d**1** and the offset d**0** of the loading position. Before the conveyor cell **12** enters the first curve **21**, the cell controller **47** moves the article P until an end portion of the article P comes into contact with the end portion (second end portion) of the load surface A with respect to the second transfer direction D2B. The cell controller **47** stores the position at which the article P stops (State **6**).

It should be noted that, for example, if the curvature radius R**1** of the first curve **21** is not less than the first threshold value, the cell controller **47** may move the article P such that the placement position of the article P on the load surface A is moved from that in State **7** in FIG. **8** to a substantially middle position shown in State **8**. The cell controller **47** may also maintain the placement position of the article P on the load surface A at this point in time.

It should be noted that, for example, if the curvature radius R**1** of the first curve **21** is not less than the first threshold value, and the chute **81** corresponding to the classification destination of the article P is present in the first sorting portion **15**, the cell controller **47** may move the position of the article P to a position that is appropriate for the position of that chute **81** relative to the conveyance path **11**. As in State **9** and State **10** shown in FIG. **9**, the cell controller **47** drives the cross belt **61** such that the center position of the article P is adjusted to a position that is offset from the middle position of the load surface A to a side closer to the chute **81** by the predetermined distance d**1**. For example, before the conveyor cell **12** enters the first curve **21**, the cell controller **47** moves the article P until an end portion of the article P comes into contact with the end portion (first end portion) of the load surface A with respect to the first transfer direction D2A.

When the conveyor cell **12** on which the article P is loaded has passed through the first curve **21** (e.g., immediately after passing therethrough), the controller **17** instructs the cell controller **47** to adjust the position of the article P on the load surface A to a predetermined position appropriate for the first sorting portion **15** or the second curve **22**.

If the chute **81** corresponding to the classification destination of the article P loaded on the conveyor cell **12** is present in the first sorting portion **15**, the controller **17** adjusts the position of the article P on the load surface A to a predetermined position appropriate for the position of the chute **81** relative to the conveyance path **11**. The predetermined position is the position at which the center position of the article P is offset from the middle position of the load surface A to the side closer to the chute **81** by the predetermined distance d**1**. The cell controller **47** stores the position at which the article P stops.

For example, if the chute **81** is located on the right side of the conveyance path **11** as viewed in the first conveyance direction D**1**, the cell controller **47** adjusts the position of the article P when the conveyor cell **12** enters the first sorting portion **15** to a position at which the end portion of the article P comes into contact with the first end portion of the load surface A with respect to the first transfer direction D2A. For example, if the chute **81** is located on the left side of the conveyance path **11** as viewed in the first conveyance direction D1, the cell controller **47** adjusts the position of the article P when the conveyor cell **12** enters the first sorting portion **15** to a position at which the end portion of the article P comes into contact with the second end portion of the load surface A with respect to the second transfer direction D2B.

When the conveyor cell **12** on which the article P is loaded enters the first sorting portion **15** having the chute **81** corresponding to the classification destination of the article P, the controller **17** instructs the cell controller **47** of the conveyor cell **12** to release the article P into the chute **81**. The cell controller **47** of the conveyor cell **12** drives the cross belt **61** in accordance with the instruction from the controller **17** and releases the article P on the load surface A of the cross belt **61** into the chute **81**.

If the chute **81** corresponding to the classification destination of the article P loaded on the conveyor cell **12** is not present in the first sorting portion **15**, the controller **17** adjusts the position of the article P on the load surface A to a predetermined position appropriate for the second curve **22**. In accordance with the control instruction from the controller **17**, the cell controller **47** controls driving of the cross belt **61**, if necessary, such that the position of the article P on the load surface A is adjusted to the predetermined position that is appropriate for the curvature radius R2 of the second curve **22**. Since the curvature radius R2 of the second curve **22** is not less than the first threshold value, the cell controller **47** does not execute control of driving of the cross belt **61** appropriate for the curvature radius R2 of the second curve **22**. If the chute **81** corresponding to the classification destination of the article P is present in the second sorting portion **16** downstream of the second curve **22**, the cell controller **47** adjusts the position of the article P to a position that is appropriate for the position of the chute **81** relative to the conveyance path **11**. The cell controller **47** drives the cross belt **61** such that the center position of the article P is adjusted to a position that is offset from the middle position of the load surface A to a side closer to the chute **81** by the predetermined distance d1. Before the conveyor cell **12** enters the second curve **22**, the cell controller **47** controls driving of the cross belt **61** in such a manner as to move the article P until an end portion of the article P comes into contact with an end portion (first or second end portion) of the load surface A that is closer to the classification destination.

It should be noted that, for example, if the curvature radius R2 of the second curve **22** is less than the first threshold value, the cell controller **47** drives the cross belt **61** such that the center position of the article P is adjusted to a position that is offset from the middle position of the load surface A to the inward side with respect to the radial direction of the second curve **22** by the predetermined distance d1. Thus, the cell controller **47** adjusts the position of the article P on the load surface A when the conveyor cell **12** enters the second curve **22** to the inner end portion with respect to the radial direction of the second curve **22**.

When the conveyor cell **12** on which the article P is loaded has passed through the second curve **22** (e.g., immediately after passing therethrough), the controller **17** instructs the cell controller **47** to adjust the position of the article P on the load surface A to a predetermined position that is appropriate for the second sorting portion **16**. The controller **17** adjusts the position of the article P on the load surface A to the predetermined position that is appropriate for the position of the chute **81** relative to the conveyance path **11**. The controller **17** adjusts the position of the article P on the load surface A to a position that is offset from the middle position to a side closer to the chute **81**. In accordance with the control instruction from the controller **17**, the cell controller **47** controls driving of the cross belt **61**, if necessary, such that the position of the article P on the load surface A when the conveyor cell **12** enters the second sorting portion **16** is adjusted to a position that is offset from the middle position to the side closer to the chute **81**. The predetermined position is the position at which the center position of the article P is offset from the middle position of the load surface A to the side closer to the chute **81** by the predetermined distance d1. The cell controller **47** stores the position at which the article P stops.

For example, if the chute **81** is located on the right side of the conveyance path **11** as viewed in the first conveyance direction D1, the cell controller **47** adjusts the position of the article P when the conveyor cell **12** enters the second sorting portion **16** to a position at which the end portion of the article P comes into contact with the first end portion of the load surface A with respect to the first transfer direction D2A. For example, if the chute **81** is located on the left side of the conveyance path **11** with respect to the first conveyance direction D1, the cell controller **47** adjusts the position of the article P when the conveyor cell **12** enters the second sorting portion **16** to a position at which the end portion of the article P comes into contact with the second end portion of the load surface A with respect to the second transfer direction D2B.

When the conveyor cell **12** on which the article P is loaded enters the second sorting portion **16** having the chute **81** corresponding to the classification destination of the article P, the controller **17** instructs the cell controller **47** of the conveyor cell **12** to release the article P into the chute **81**. The cell controller **47** of the conveyor cell **12** drives the cross belt **61** in accordance with the instruction from the controller **17** and releases the article P on the load surface A of the cross belt **61** into the chute **81**.

According to the above-described embodiment, the position of the article P on the load surface A is shifted before entry into a curve, and thus the article P can properly pass through curves of various shapes. With the controller **17** that moves the position of the article P on the load surface A to a position that is offset from the middle position in the second conveyance direction in accordance with the curvature radius of a curve, the position of the article P can be made appropriate in accordance with the centrifugal force acting on the article P and the friction force between the article P and the load surface A. With the controller **17** that makes the position of the article P on the load surface A appropriate for curves of various shapes, the necessity to increase the curvature radius of each curve is eliminated, so that the size of the article sorting apparatus **10** can be reduced. Moreover, even an article P with a high center of gravity does not fall over, or even a round article P can be prevented from rolling. Furthermore, the necessity to reduce the conveyance speed of each conveyor cell **12** is eliminated, so that the processing speed of the article sorting apparatus **10** can be increased.

Furthermore, with the controller **17** that adjusts the position of the article P on the load surface A to a position that is offset from the middle position to the inward side with respect to the radial direction of a curve if the curvature radius of the curve is less than the first threshold value, the centrifugal force of the article P can be significantly reduced by reducing the radius of gyration of the article P. With the controller **17** that reduces the centrifugal force acting on the article P if the curvature radius of a curve is less than the first threshold value, the centrifugal force of the article P is prevented from becoming larger than the friction force between the article P and the load surface A, so that the article P can be prevented from starting to slide on the load surface A.

Furthermore, with the controller **17** that sets the first threshold value in accordance with the length LA of the load surface A and the curvature radius R of a curve, it is possible to properly discriminate between a curve with respect to which a reduction in the centrifugal force of the article is effective and a curve with respect to which an increase in the moving distance of the article on the load surface A is effective.

Furthermore, with the controller **17** that adjusts the position of the article P on the load surface A of each conveyor cell **12** to a position that is offset to a side closer to the chute **81** corresponding to the classification destination of the article P, the working efficiency of the article sorting apparatus **10** can be improved. Furthermore, the time that is taken to load the article P into the chute **81** can be reduced, so that the load on the motor **68** during loading of the article P into the chute **81** can be reduced. Furthermore, with the controller **17** that adjusts the position of the article P on the load surface A to a position that is offset from the middle position to a side closer to the classification destination of the article P that is present downstream of a curve if the curvature radius of that curve is not less than the first threshold value, the working efficiency of the article sorting apparatus **10** can be improved.

Furthermore, with the controller **17** that sets the position that is offset from the middle position on the load surface A with respect to the second conveyance direction to be the position at which the end portion of the article P comes into contact with the first end portion or the second end portion of the load surface A, the centrifugal force of the article P at the curve is significantly reduced, so that the operation efficiency at the chute **81** can be improved.

Furthermore, with the controller **17** that, if the curvature radius of the curve is not less than the first threshold value, shifts the position of the article P on the load surface A to the middle position or maintains the position of the article P at this point in time, excessive shifting of the position of the article P can be prevented if the centrifugal force of the article P is minute.

Furthermore, with the controller **17** that moves the article P based on the offset d**0** of the loading position, which is detected by the article position acquisition portion **14**, the length LP of the article P, which is detected by the article length sensor **74**, and the known length LA of the load surface A, the positional accuracy of the article P can be improved.

Furthermore, with the noncontact feeding portion **34** that feeds power from the conveyance path **11** to each conveyor cell **12** in a contactless manner, power can be easily fed to each of the plurality of conveyor cells **12** moving along the conveyance path **11**. Furthermore, with the controller **17** that sets the position of the article P on the load surface A when the article P is transferred from the loading portion **13** to the conveyor cell **12**, it is possible to move the article P on the load surface A using the power that is fed in order to transfer the article P. Furthermore, with the controller **17** that sets the position of the article P on the load surface A immediately after the article P has passed through a curve upstream of the target curve, early setting of the position of the article P on the load surface A can be performed.

Hereinafter, modifications will be described. In the foregoing embodiment, the article position acquisition portion **14** that detects the position of the article P on the load surface A of each conveyor cell **12** is provided; however, the present invention is not limited to this. In the article sorting apparatus **10** according to a first modification of the embodiment, each conveyor cell **12** may include a first optical sensor **45***a* and a second optical sensor **45***b* that are provided in the frame portion **43**, as shown in FIG. **10**. It should be noted that State **6-2** and State **10-2** shown in FIG. **10** correspond to State **6** shown in FIG. **7** and State **9** shown in FIG. **9** that are described above. The first optical sensor **45***a* is disposed at the first end portion of the load surface A with respect to the second conveyance direction or a position that is offset from the middle position thereof toward the first end portion. The second optical sensor **45***b* is disposed at the second end portion of the load surface A with respect to the second conveyance direction or a position that is offset from the middle position thereof toward the second end portion. For example, the first optical sensor **45***a* and the second optical sensor **45***b* may be optical sensors of a transmission type, a reflection type, a proximity type, or the like.

For example, the first optical sensor **45***a* has its optical axis at the first end portion of the load surface A with respect to the first transfer direction D**2**A, the optical axis being located above the load surface A and extending in the front-rear direction that is orthogonal to the first transfer direction D**2**A. The second optical sensor **45***b* has its optical axis at the second end portion of the load surface A with respect to the second transfer direction D**2**B, the optical axis being located above the load surface A and extending in the front-rear direction that is orthogonal to the second transfer direction D**2**B. The first optical sensor **45***a* and the second optical sensor **45***b* are operated by power that is fed from the battery **44**.

Each of the first optical sensor **45***a* and the second optical sensor **45***b* includes, if the optical sensors are optical sensors of a transmission type, for example, a light emitting portion and a light receiving portion that are arranged opposing each other in the front-rear direction that is orthogonal to the first transfer direction D**2**A and the second transfer direction D**2**B. Irradiation light that is output from the light emitting portion is received by the light receiving portion if no article P is present on the optical axis. Each of the first optical sensor **45***a* and the second optical sensor **45***b* outputs an ON signal if an article P is present on the optical axis of the irradiation light that is output from the light emitting portion, and the receipt of the irradiation light by the light receiving portion is thus interrupted. Each of the first optical sensor **45***a* and the second optical sensor **45***b* outputs an OFF signal if no article P is present on the optical axis of the irradiation light that is output from the light emitting portion, and the light receiving portion continues receiving the irradiation light.

In accordance with a control instruction that is output from the controller **17**, the cell controller **47** of each conveyor cell **12** controls driving of the motor **68** in accordance with the ON/OFF signal that is output from each of the first optical sensor **45***a* and the second optical sensor **45***b*. With respect to the movement of the article P on the load surface A that is instructed by the controller **17**, the cell controller **47** moves the article P until the article P is detected by the first optical sensor **45***a* or the second optical sensor **45***b*.

For example, during delivery of the article P from each injector **71** of the loading portion **13** to a given conveyor cell **12**, the cell controller **47** detects the transfer state of the article P in accordance with a change in the output of the first optical sensor **45***a* on the side closer to the injector **71** with respect to the second conveyance direction. If the output of the first optical sensor **45***a* changes from the OFF signal to the ON signal, the cell controller **47** detects that loading of the article P onto the first end portion on the load surface A is started. Next, if the output of the first optical sensor **45***a* changes from the ON signal to the OFF signal, the cell controller **47** detects that the article P has been loaded to the middle position side with respect to the first end portion of the load surface A. The loading portion **13** stops driving of the injector **71** if the cell controller **47** detects that the entire article P is placed on the middle position side with respect to the first end portion of the load surface A.

The cell controller **47**, when moving the position of the article P on the load surface A to a position that is offset from the middle position in the second conveyance direction, controls driving of the cross belt **61** in accordance with the ON/OFF signal output from each of the first optical sensor **45***a* and the second optical sensor **45***b*. For example, the cell controller **47** uses the ON/OFF signal of each of the first optical sensor **45***a* and the second optical sensor **45***b* when moving the article P on the load surface A as appropriate for each curve on the conveyance path **11** and the chute **81** corresponding to the classification destination of the article P.

For example, the cell controller **47** drives the cross belt **61** in the first transfer direction D**2**A until the output of the first optical sensor **45***a* changes from the OFF signal to the ON signal. If the output of the first optical sensor **45***a* changes from the OFF signal to the ON signal, the cell controller **47** judges that the article P has reached the first end portion on the load surface A and stops driving of the cross belt **61**. For example, the cell controller **47** drives the cross belt **61** in the second transfer direction D**2**B until the output of the second optical sensor **45***b* changes from the OFF signal to the ON signal. If the output of the second optical sensor **45***b* changes from the OFF signal to the ON signal, the cell controller **47** judges that the article P has reached the second end portion on the load surface A and stops driving of the cross belt **61**.

For example, since the curvature radius R1 of the first curve **21** is less than the first threshold value, before the entry of the conveyor cell **12** into the first curve **21**, the cell controller **47** drives the cross belt **61** in the second transfer direction D2B until the output of the second optical sensor **45***b* changes from the OFF signal to the ON signal. If the output of the second optical sensor **45***b* changes from the OFF signal to the ON signal, the cell controller **47** stops driving of the cross belt **61**, thereby stopping the article P in a state in which the end portion of the article P is in contact with the second end portion of the load surface A. The cell controller **47** stores the position at which the article P stops.

According to the first modification of the embodiment, with the controller **17** that moves the article P on the load surface A until the article P is detected by each of the first optical sensor **45***a* and the second optical sensor **45***b*, the article P can be easily and accurately moved to a desired position. Furthermore, with the first optical sensor **45***a* and the second optical sensor **45***b* that are provided at the first end portion and the second end portion, respectively, of the load surface A with respect to the second conveyance direction, the article P can be easily and accurately moved to both end portions of the load surface A with respect to the second conveyance direction.

In the above-described first modification, it is also possible that only one of the first optical sensor **45***a* and the second optical sensor **45***b* is provided. Although the first optical sensor **45***a* and the second optical sensor **45***b* are provided in the above-described first modification, the present invention is not limited to this, and pressure sensors that are attached to or incorporated in the cross belt **61** or the belt support board **64** may also be provided as an alternative or in addition to the optical sensors. Moreover, in the case where the temperature of the article P is higher or lower than that of the surrounding environment, thermal sensors may be provided as an alternative or in addition to the optical sensors.

In the above-described first modification, the first optical sensor **45***a* and the second optical sensor **45***b* are provided in each conveyor cell **12**; however, the present invention is not limited to this. In the article sorting apparatus **10** according to a second modification of the embodiment, as shown in FIG. **11**, a first optical sensor **91***a* and a second optical sensor **91***b* may also be provided on the conveyance path **11**. It should be noted that State **6-3** and State **10-3** shown in FIG. **11** correspond to State **6** shown in FIG. **7** and State **9** shown in FIG. **9** that are described above. The first optical sensor **91***a* is disposed on the conveyance path **11** on an outward side of the first end portion of the load surface A with respect to the second conveyance direction. The second optical sensor **91***b* is disposed on the conveyance path **11** on an outward side of the second end portion of the load surface A with respect to the second conveyance direction. The first optical sensor **91***a* and the second optical sensor **91***b* may be, for example, optical sensors of a transmission type, a reflection type, a proximity type, or the like. The first optical sensor **91***a* and the second optical sensor **91***b* detect whether any portion of the article P protrudes beyond the load surface A.

For example, the first optical sensor **91***a* has its optical axis extending upward in the vertical direction at a position on the outward side of the first end portion of the load surface A with respect to the first transfer direction D**2**A. For example, the second optical sensor **91***b* has its optical axis extending upward in the vertical direction at a position on the outward side of the second end portion of the load surface A with respect to the second transfer direction D**2**B. The first optical sensor **91***a* and the second optical sensor **91***b* are operated by power that is fed from the conveyance path **11**.

Each of the first optical sensor **91***a* and the second optical sensor **91***b* includes, if the optical sensors are optical sensors of a reflection type, for example, a light emitting portion and a light receiving portion that are disposed facing upward in the vertical direction. Irradiation light that is output upward in the vertical direction from the light emitting portion is reflected by an article P if that article P is present on the optical axis, and then received by the light receiving portion. Each of the first optical sensor **91***a* and the second optical sensor **91***b* outputs an ON signal if an article P is present on the optical axis of the irradiation light that is output from the light emitting portion, and thus the light receiving portion continues receiving reflection light that is obtained by the irradiation light being reflected by the article P. Each of the first optical sensor **91***a* and the second optical sensor **91***b* outputs an OFF signal if no article P is present on the optical axis of the irradiation light that is output from the light emitting portion, and thus receipt of the reflection light by the light receiving portion is interrupted.

When moving the position of the article P on the load surface A to a position that is offset from the middle position in the second conveyance direction, the cell controller **47** controls driving of the cross belt **61** in accordance with the ON/OFF signal output from each of the first optical sensor **91***a* and the second optical sensor **91***b*. For example, the cell controller **47** uses the ON/OFF signal from each of the first optical sensor **91***a* and the second optical sensor **91***b* when moving the article P on the load surface A as appropriate for each curve of the conveyance path **11** and the chute **81** corresponding to the classification destination of the article P.

For example, the cell controller **47** drives the cross belt **61** in the first transfer direction D**2**A until the output of the first optical sensor **91***a* changes from the OFF signal to the ON signal. If the output of the first optical sensor **91***a* changes from the OFF signal to the ON signal, the cell controller **47** judges that a portion of the article P has reached a position at which it protrudes outward from the first end portion on the load surface A, and stops driving of the cross belt **61**. For example, the cell controller **47** drives the cross belt **61** in the second transfer direction D**2**B until the output of the second optical sensor **91***b* changes from the OFF signal to the ON signal. If the output of the second optical sensor **91***b* changes from the OFF signal to the ON signal, the cell controller **47** judges that the article P has reached a position at which it protrudes outward from the second end portion on the load surface A, and stops driving of the cross belt **61**.

Since the first optical sensor **91***a* and the second optical sensor **91***b* detect the portion of the article P that protrudes outward from the load surface A with respect to the second conveyance direction, the center position of the article P on the load surface A is the position that is offset from the middle position of the load surface A by a predetermined distance d**2** (>d**1**) that is larger than the predetermined distance d**1**. According to the second modification, each conveyor cell **12** is not required to have the first optical sensor **45***a* and the second optical sensor **45***b* and thus can convey an article that is larger than the load surface A with respect to the first conveyance direction D**1** (i.e., article that protrudes from the load surface A in the first conveyance direction D**1**).

In the above-described second modification, it is also possible that only one of the first optical sensor **91***a* and the second optical sensor **91***b* is provided. In the above-described second modification, it is also possible that the article sorting apparatus **10** includes a plurality of pairs of first and second optical sensors **91***a* and **91***b* that are continuously or discontinuously arranged along the entire length of the conveyance path **11**. Moreover, it is also possible that the article sorting apparatus **10** includes at least one pair of first and second optical sensors **91***a* and **91***b* that is disposed in a portion of the conveyance path **11**. The article sorting apparatus **10** may also include a first optical sensor **91***a* and a second optical sensor **91***b* at least at a location on the conveyance path **11** where the controller **17** sets the position of the article P on the load surface A. The article sorting apparatus **10** may also include a first optical sensor **91***a* and a second optical sensor **91***b* around each of the loading portion **13**, the first sorting portion **15** and the second sorting portion **16**, as well as the first curve **21** and the second curve **22**, for example.

In the above-described embodiment, each conveyor cell **12** may also include a rotation sensor that detects the angle of rotation of the motor **68**. In this case, the cell controller **47** may calculate the position of the article P on the load surface A in the second conveyance direction based on the angle of rotation of the motor **68** that is detected by the rotation sensor. The cell controller **47** may calculate the distance for which the article P needs to be moved in order to move the article P from the calculated position of the article P to the predetermined position in the second conveyance direction (i.e., position that is offset from the middle position on the load surface A in the second conveyance direction), and move the article P for the calculated distance.

Although a high-speed camera is used as the article position acquisition portion **14** in the above-described embodiment, the present invention is not limited to this. For example, another camera or a position sensor such as a line sensor may also be used as the article position acquisition portion **14**.

Although the conveyance path **11** having the configuration shown in FIG. **1** is used in the above-described embodiment, the present invention is not limited to this. In a modification of the embodiment, for example, the conveyance path **11** may have each of the loading portion **13**, the article position acquisition portion **14**, and the sorting portions at one location or a plurality of locations. For example, with respect to the conveyance path **11**, the number of curves, the direction of each curve, and the shape of each curve may be set as desired, and an upward slope or a downward slope may also be provided if necessary.

Although the conveyance path **11** includes the first curve **21**, the second curve **22**, the third curve **23**, and the fourth curve **24** in the above-described embodiment, the present invention is not limited to this, and the number of curves provided in the conveyance path **11** and the shape of each curve may be changed appropriately. Moreover, although the article sorting apparatus **10** in the foregoing description includes the loading portion **13**, the article position acquisition portion **14**, the first sorting portion **15**, and the second sorting portion **16** that are arranged along the conveyance path **11**, the present invention is not limited to this, and the numbers of loading portions, information acquisition portions, and sorting portions may be changed appropriately. For example, a second loading portion may also be added between the first sorting portion **15** and the second sorting portion **16**. In this case, the processing speed of the article sorting apparatus **10** may be improved by adopting a configuration in which immediately after a conveyor cell **12** is emptied by loading the article P thereon into the chute **81** in the first sorting portion **15**, an article P is loaded onto that conveyor cell **12** from the second loading portion.

Although the conveyance path **11** and the plurality of conveyor cells **12** include the linear synchronous motor **31** in the above-described embodiment, the present invention is not limited to this, and it is also possible that a linear induction motor is included. Moreover, it is also possible that each conveyor cell **12** includes a driving wheel and a motor that drives and rotates the driving wheel, instead of the linear synchronous motor **31**, and travels along the conveyance path **11** using the motor as a traveling driving source. Moreover, it is also possible that each conveyor cell **12** is conveyed along the conveyance path **11** by a transmission mechanism that mechanically transmits the driving force, instead of the linear synchronous motor **31**. For example, a configuration may be adopted in which a flat plate is provided extending downward in the vertical direction from the chassis **51** of the chassis portion **41**, an end portion of the flat plate is sandwiched between a pair of rollers that are driven and rotated by a motor and that are located on opposite sides of the end portion with respect to the thickness direction thereof, and thus the driving force in the first conveyance direction D**1** is obtained.

Although the noncontact feeding portion **34** is provided along the entire length of the conveyance path **11** in the above-described embodiment, the present invention is not limited to this, and it is also possible that the noncontact feeding portion **34** is provided in a portion of the conveyance path **11**. The noncontact feeding portion **34** may be provided at least around each of the loading portion **13**, the first sorting portion **15** and the second sorting portion **16**, as well as the first curve **21** and the second curve **22** (e.g., around the exit of each of the first curve **21** and the second curve **22**, etc.). In the above-described embodiment, it is also possible that adjacent conveyor cells **12** are connected to each other by a cable through which power that is fed from the noncontact feeding portion **34** or control signals are transmitted. In the above-described embodiment, it is also possible that each conveyor cell **12** includes, with respect to the power that is fed from the noncontact feeding portion **34**, an AC/DC converter that converts the power to direct current, a transformer that increases or reduces the voltage, a rectifying accumulator, and a capacitor, a battery, and the like for accumulating electricity.

In the above-described embodiment, the noncontact feeding portion **34** feeds power from the conveyance path **11** to each conveyor cell **12** in a contactless manner by electromagnetic induction; however, the present invention is not limited to this. For example, the noncontact feeding portion **34** may also feed power from the conveyance path **11** to each conveyor cell **12** in a contactless manner by radio transmission and reception, magnetic field resonance, electric field coupling, or the like.

In the above-described embodiment, conveyor cells **12** that are adjacent to each other on the front side and the rear side in the first conveyance direction D**1** are coupled to each other by their respective connection mechanisms **53**; however, the present invention is not limited to this, and the plurality of conveyor cells **12** may be separate from and independent of each other.

In the above-described embodiment, a servo motor is used as the motor **68**; however, the present invention is not limited to this, and, for example, a DC motor, a brushless DC motor, a stepping motor, or the like may also be used as the motor **68**.

In the above-described embodiment, the cross belt mechanism **42** may also include a tension adjustment mechanism that adjusts the tension of the cross belt **61** by adjusting the distance between the driving roller **62** and the driven roller **63**. Moreover, the cross belt mechanism **42** may also include a tension roller that adjusts the tension of the cross belt **61**, in addition to the driving roller **62** and the driven roller **63**.

In the above-described embodiment, each chute **81** in the first sorting portion **15** and the second sorting portion **16** may also include a conveyance portion such as a belt conveyor that is operable to draw in the article P released from the cross belt **61** of each conveyor cell **12**.

In the above-described embodiment, the article position acquisition portion **14** includes the information acquisition portion **14***a* that is configured integrally therewith; however, the present invention is not limited to this. In a modification of the embodiment, the information acquisition portion may be provided independently of the article position acquisition portion **14**. For example, the information acquisition portion may be disposed in the loading portion **13**, between the loading portion **13** and the first sorting portion **15** on the conveyance path **11**, upstream of the article sorting apparatus **10** on a conveyance route of the article P, or the like.

It should be noted that in the above-described embodiment, before entry of a conveyance unit into a curve, if the curvature radius of the curve is less than a predetermined threshold value, the position of the article on the load surface of the conveyance unit is moved from the loading position or the placement position on the conveyance unit to a position that is offset from the middle position on the load surface to the inward side with respect to the radial direction of the curve; however, the following control may also be performed. That is to say, during loading of an article from the loading portion to a conveyance unit, since the curvature radius of the next curve is known, if that curvature radius is less than the predetermined threshold value, the loading position to which the article is loaded from the loading portion is adjusted to a position that is offset from the middle position on the load surface of the conveyance unit to the inward side with respect to the radial direction of that curve. In this manner, the necessity to move the article immediately before the conveyance unit enters the curve is eliminated. As a result, it is not necessary to provide the noncontact feeding portion that feeds power from the conveyance path to the conveyance unit in a contactless manner immediately before the curve.

According to the at least one embodiment described above, with the controller **17** that sets the position of the article P on the load surface A in accordance with the curvature radius of each curve, each conveyor cell **12** can properly pass through curves of various shapes while changing the position of the article P on the load surface A. With the controller **17** that moves the position of the article P on the load surface A to a position that is offset from the middle position in the second conveyance direction in accordance with the curvature radius of each curve, the position of the article P can be made appropriate in accordance with the centrifugal force acting on the article P and the friction force between the article P and the load surface A. With the controller **17** that makes the position of the article P on the load surface A appropriate for curves of various shapes, the necessity to increase the curvature radius of each curve is eliminated, so that the size of the article sorting apparatus **10** can be reduced, and also the processing speed of the article sorting apparatus **10** can be increased.

Furthermore, with the controller **17** that, if the curvature radius of a curve is less than the first threshold value, moves the position of the article P on the load surface A to a position that is offset from the middle position to the inward side with respect to the radial direction of the curve, the centrifugal force of the article P can be significantly reduced by increasing the radius of gyration of the article P. With the controller **17** that, if the curvature radius of a curve is less than the first threshold value, reduces the centrifugal force acting on the article P, the centrifugal force of the article P can be prevented from becoming larger than the friction force between the article P and the load surface A, so that the article P can be prevented from starting to slide on the load surface A. Thus, the working efficiency of the article sorting apparatus **10** can be improved, and also the overall throughput of a distribution system can be improved.

Furthermore, with the controller **17** that moves the position of the article P on the load surface A of each conveyor cell **12** to a position that is offset to a side closer to the chute **81** corresponding to the classification destination of the article P, the working efficiency of the article sorting apparatus **10** can be improved. Furthermore, the time that is taken to load the article P into the chute **81** can be reduced, and the load on the motor **68** during loading of the article P into the chute **81** can be reduced.

While certain embodiments of the present invention have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. An article sorting apparatus, comprising:

a conveyance path extending in a first conveyance direction, the conveyance path having a curve;

a conveyance unit that moves along the conveyance path and conveys an article loaded on the conveyance unit in a second conveyance direction that intersects the first conveyance direction of the conveyance path;

a loading portion that loads the article onto the conveyance unit;

a sorting portion that sorts the article conveyed by the conveyance unit; and

a controller that controls movement of the conveyance unit in the first conveyance direction and conveyance of the article in the second conveyance direction and controls the conveyance unit before entry of the conveyance unit into the curve such that if the curve has a curvature radius that is less than a predetermined threshold value, the position of the article on a load surface of the conveyance unit on which the article is placed is adjusted to a position that is offset from a middle position on the load surface to an inward side with respect to a radial direction of the curve.

2. The apparatus according to claim 1, wherein the controller controls the conveyance unit such that if the curve has a curvature radius that is not less than the predetermined threshold value, and a sorting destination of the article in the sorting portion is located downstream of the curve in the first conveyance direction, the position of the article on the load surface is adjusted to a position that is offset from the middle position on the load surface to a side closer to the sorting destination.

3. The apparatus according to claim 2, wherein the controller controls the conveyance unit such that if the curve that is located immediately before the sorting destination in the first conveyance direction has a curvature radius that is less than the predetermined threshold value, the position of the article on the load surface is adjusted to a position that is offset from the middle position on the load surface to the inward side with respect to the radial direction of the curve.

4. The apparatus according to claim 1, wherein the controller sets the predetermined threshold value in accordance with a length of the load surface in the second conveyance direction and the curvature radius of the curve.

5. The apparatus according to claim 1, wherein the controller sets the position that is offset from the middle position on the load surface in the second conveyance direction to be a position at which an end portion of the article coincides with at least one of a first end portion and a second end portion of the load surface with respect to the second conveyance direction.

6. The apparatus according to claim 1, further comprising:

a position sensor that detects the position of the article on the load surface,

wherein, based on the position of the article that is detected by the position sensor, the controller acquires a distance for which the article needs to be moved in order to move the article to the position that is offset from the middle position on the load surface in the second conveyance direction and moves the article for the acquired distance.

7. The apparatus according to claim 1, further comprising:

a sensor that is disposed at a position offset from the middle position in the second conveyance direction and that detects whether the article is present,

wherein the controller moves the article until the article is detected by the sensor.

8. The apparatus according to claim 7, wherein the sensor is disposed in the conveyance unit and detects whether the article is present on at least one of the first end portion and the second end portion of the load surface with respect to the second conveyance direction.

9. The apparatus according to claim 7, wherein the sensor is disposed on the conveyance path and detects whether the article is present at a position on an outward side of the load surface with respect to the second conveyance direction beyond at least one of the first end portion and the second end portion of the load surface with respect to the second conveyance direction.

10. The apparatus according to claim 9, wherein a plurality of said sensors are arranged continuously or discontinuously along the entire length of the conveyance path.

11. The apparatus according to claim 1, further comprising:

a noncontact feeding portion that is disposed at least around the loading portion, around the sorting portion, and upstream of the curve and that feeds power from the conveyance path to the conveyance unit in a contactless manner.

12. An article sorting apparatus, comprising:

a conveyance path extending in a first conveyance direction, the conveyance path having a curve;

a conveyance unit that moves along the conveyance path and conveys an article loaded on the conveyance unit in a second conveyance direction that intersects the first conveyance direction of the conveyance path;

a loading portion that loads the article onto the conveyance unit;

a sorting portion that sorts the article conveyed by the conveyance unit; and

a controller that controls movement of the conveyance unit in the first conveyance direction and conveyance of the article in the second conveyance direction and controls the conveyance unit such that if the curve that is located downstream of the loading portion in the first conveyance direction has a curvature radius that is less than a predetermined threshold value, the position of the article that is loaded onto the conveyance unit from the loading portion is a position that is offset from a middle position on a load surface to an inward side with respect to a radial direction of the curve.

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